CONTACT?
Signals from space look like the real thing

NewScientist

WEEKLY April 4 - 10, 2015

SPECIAL REPORT

BELIEF

THEY DRIVE EVERYTHING WE DO. BUT OUR BELIEFS ARE BUILT ON...

...NOTHING

No3015 US$5.95 CAN$5.95

ANCIENT ANTIBIOTICS
Medieval cure for modern superbugs

CAMERA NEVER LIES?
Lensless photography gives you the full picture

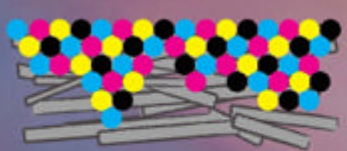
WET AND WEIRD
The power of water's strangeness

ALL PAPER IS NOT CREATED EQUAL.

Especially in business, looking good on paper really matters. ColorLok® Technology gives paper more vivid colours, bolder blacks, and faster drying times.* So make a strong impression by choosing paper with the ColorLok logo. **Learn more at colorlok.com**

THE SCIENCE OF WOWING YOUR CUSTOMERS

ColorLok Technology turns everyday office paper into your canvas for eye-popping imagery and incredibly professional presentations. How? By injecting additives during the paper-making process that enable the paper to "lock" pigments at the surface. Without this technology, paper acts more like a sponge, absorbing black and colour pigments deep into the fibres of the paper and away from the surface.



Without ColorLok Technology, pigment sinks deep into the paper's fibres. Black appears duller and colours less vibrant.

When you print on paper with ColorLok Technology, the additives within the paper react with the pigments, keeping colour near the surface for bold, vivid results.

A NEW LOOK FOR ECO-FRIENDLY PAPER

Even recyclable paper looks better than ever, because ColorLok Technology creates a shield between the surface and subsurface fibres. Printouts on recycled paper can now retain a brighter, richer appearance, so you can be eco-friendly without compromising quality. What's more, paper with ColorLok Technology is actually easier to recycle. So yes, you can look good and do good.

*Independent testing by SpencerLab Digital Color Laboratory, commissioned by HP. The full October 2009 report, "Print Quality Analyses – ColorLok Media Evaluation: AiO Printers: Brother MFC-5490CN, Canon PIXMA MX860 & MX7600, Epson WorkForce 600, HP Officejet 6500 and Officejet Pro 8500," is available for download at spencerlab.com


VIVID COLOURS
Richer, brighter images and graphics on all your printers
BOLDER BLACKS
Means crisper, sharper text and lines than with standard paper
FASTER DRYING
Less smear and faster handling compared to papers without ColorLok Technology
ECO-FRIENDLY
Easier to recycle, with results that don't look dull
CONSISTENCY
Consistent and reliable printing regardless of which machine is used
FASTER DRYING
BOLDER BLACKS
ColorLok
TECHNOLOGY
VIVID COLORS
®

CONTENTS

Volume 226 No 3015

This issue online
newscientist.com/issue/3015

News

8

Cosmic contact?

Alien origin suggested for strange radio bursts from space

ROGER RESSMEYER/CORBIS

On the cover

28

Special report: Belief

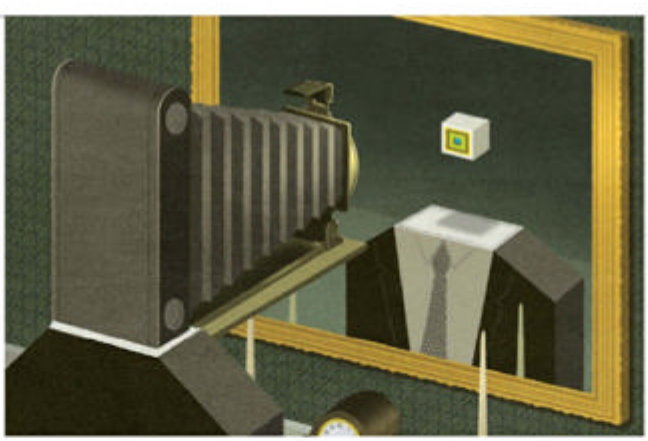
They drive everything we do. But our beliefs are built on... nothing

Features

34

Photo finish

In the age of the selfie, the camera as we know it is changing forever



MICHAEL GLENWOOD

Coming next week...

Quantum purity
The principle that rids the world of weirdness

Not to be sneezed at
How to fight back against hay fever

NewScientist Connect

LET YOUR LOVE LIFE LIFT OFF

ON

NEW SCIENTIST CONNECT

Join now FOR FREE

We all know it's not rocket science trying to find that special someone with whom we connect, even though it sometimes feels that way. Which is why we've launched New Scientist Connect.

Meet like-minded people who share similar interests to you – whether you're looking for love, or just to meet someone on the same wavelength, no matter where you are in the world.

Launch your search now at: http://dating.newscientist.com

NewScientist

LOCATIONS
USA
225 Wyman Street,
Waltham, MA 02451
Please direct telephone enquiries to our UK office +44 (0) 20 7611 1200

UK
110 High Holborn,
London, WC1V 6EU
Tel +44 (0) 20 7611 1200
Fax +44 (0) 20 7611 1250

Australia
Tower 2, 475 Victoria Avenue,
Chatswood, NSW 2067
Tel +61 2 9422 8559
Fax +61 2 9422 8552

SUBSCRIPTION SERVICE
For our latest subscription offers, visit **newscientist.com/subscribe**

Customer and subscription services are also available by:

Telephone 1-888-822-3242

Email subscribe@newscientist.com

Web newscientist.com/subscribe

Mail New Scientist, PO Box 3806, Chesterfield, MO 63006-9953 USA

One year subscription (51 issues) $154

CONTACTS
Contact us
newscientist.com/contact

Who's who
newscientist.com/people

General & media enquiries
enquiries@newscientist.com

Editorial
Tel 781 734 8770
news@newscientist.com
features@newscientist.com
opinion@newscientist.com

Picture desk
Tel +44 (0) 20 7611 1268

Display advertising
Tel 781 734 8770
displaysales@newscientist.com

Recruitment advertising
Tel 781 734 8770
nssales@newscientist.com

Newsstand
Tel 212 237 7987
Distributed by Time/Warner Retail Sales and Marketing, 260 Cherry Hill Road, Parsippany, NJ 07054

Syndication
Tribune Content Agency
Tel 800 637 4082

New Scientist ISSN 0262 4079 is published weekly except for the last week in December by Reed Business Information Ltd, England.

New Scientist at Reed Business Information, c/o Schnell Publishing Co. Inc., 225 Wyman Street, Waltham, MA 02451.

Periodicals postage paid at Boston, MA and other mailing offices.

Postmaster: Send address changes to New Scientist, PO Box 3806, Chesterfield, MO 63006-9953, USA.

Registered at the Post Office as a newspaper and printed in USA by Fry Communications Inc, Mechanicsburg, PA 17055

MANJUNATH KIRAN/AFP/GETTY IMAGES

Don't believe in belief

We need evidence and argument, as well as conviction

FOR millions of people around the world, this weekend is a special occasion – a time to celebrate the central article of their religious faith, Jesus's resurrection and ascension to heaven.

Not one of these people can really know what happened 2000-odd years ago in Jerusalem. And yet they believe their version of events is true. In some cases, they base their entire world view on it, and view the billions who do not share their belief as benighted.

That may seem unremarkable. Religious faith has long been considered a special category of belief. Other beliefs – in politics, say, or business – are more often thought to be the product of fact-based reasoning.

But the more we learn about how beliefs work, the less exceptional religion looks. It turns out that almost all of our beliefs are built on intuition, biases and gut instinct: yet another facet of our mental lives over which we possess less conscious control than we like to think (see page 28).

Science is not exempt. The scientific method is based on verifiable evidence, and is thus not a belief system, despite frequent claims to the contrary. But scientists, as humans, are influenced by their own beliefs about what is important, what they might find and what their findings mean. Yet it is still by far the best way to distinguish what we believe from what we know.

This new view of belief is still incomplete, but unsettling. Belief is a potent force in human affairs. It is hard to think of a major historic event not motivated by it in some way: we might not have civilisation without it (see last week's Leader). And our leaders' convictions may count as much as, or more than, their arguments.

But where should we locate our beliefs within modern society? Religion is respected as routinely as its dictates are ignored. We cannot extend the same Janus-faced attitude to all beliefs. But we can reject belief, without robust supporting evidence or argument, as an insufficient basis for politics or policy. Don't believe that belief alone is enough. ■

Seeing in a new light

CLICK. Not many of the countless cameras in the world today still have mechanical shutters, but the sound of one has persisted into the smartphone age – as a familiar signal that an instant has been captured for posterity.

We trust photographs, even if they have been manipulated. Models are Photoshopped to fit ideals of beauty; our own snaps are filtered to add glow and grain.

Now the ability to alter photos is about to leap forward once again. Replace one of the few surviving components of a traditional camera – the lens – with arrays of sensors and smart algorithms, and you can adjust the focus, lighting and even the angle of a shot (see page 34).

This "computational photography" often works by extracting or extrapolating from information that's already there. So the image is not what you saw – but not necessarily fake either.

When van Leeuwenhoek first looked through a microscope in the 17th century, what he saw was so unexpected he had to train himself to see anew (see page 44). What future cameras reveal may be equally unfamiliar – and will reshape our ideas about the authenticity of photographs.

To be sure, the camera never lies. But we may not always recognise the truth it reveals. ■

Earth twins next door?

HELLO neighbours! There could be two Earth-like planets within cosmic spitting distance of our own. Both are too close to their star to host life, but there could be other planets in the system with more temperate climates.

Alpha Centauri is a binary star system just 4.3 light years from us. In 2012, astronomers announced that the system had a planet, Alpha Centauri Bb, that was a rocky world just bigger than Earth. But in 2013, its existence was called into question.

So Brice-Oliver Demory of the University of Cambridge and his team used the Hubble Space Telescope to look for it. They had no luck but instead saw hints of a second Earth-sized world in the system.

Demory's team observed Alpha Centauri B in 2013 and 2014 for 40 hours. The 2013 data showed signs of a planet passing in front of the star, but it took longer than expected for Bb, and the statistical validity of the signal disappeared when combined with the 2014 data. That doesn't mean Bb isn't there, just that if it exists, it can't be seen passing in front of the star from Earth.

So what did the team see in 2013? The only explanation is that it is another planet in the system, probably Earth-sized, with a year lasting no more than 20.4 days. This puts it slightly further out than Bb but still scorchingly close to the star (arxiv.org/abs/1503.07528).

"If you see one planet, the chance is there are other planets in the system," says Demory – and these could be more life-friendly.

SKYSURVEY.ORG/L. CALÇADA/NICK RISINGER/ESO

What lives near Alpha Centauri B?

Bee scandal

HAS the UK government been stung? We still don't know if neonicotinoid pesticides kill bumblebees, but the latest research is alarming.

One of the UK's top bee researchers claimed last week that a study quoted two years ago by UK ministers to justify opposing a European Union ban on neonicotinoids in fact shows that the pesticides can harm the insects.

The study, by Helen Thompson of the government's Food and Environment Research Agency, found "no clear consistent relationships" between pesticide residues and measures of the health of bee colonies.

"It quite clearly showed a negative relationship between pesticide levels and colony success"

But Dave Goulson of the University of Sussex in Brighton has reanalysed the data and says the results "strongly suggest that wild bumblebee colonies in farmland can be expected to be adversely affected by exposure to neonicotinoids".

Bees are declining rapidly in the UK and elsewhere. Much attention has focussed on neonicotinoids, which are widely applied as insecticides to arable crops visited by bees. The EU temporarily banned the pesticides in 2013 after several studies demonstrated the damage caused to bumblebees fed with pesticide-laden pollen. But the Thompson study – not peer reviewed – was the first to look at bees in the wild. The UK environment minister declared, "We did not see grounds for a ban based on our field trial data."

Goulson now says the data "quite clearly showed a negative relationship between pesticide levels and colony success" (*PeerJ*, doi.org/286). The study found 50 per cent fewer new queens in the hives near the pesticide-soaked fields.

"This is a scandal," says Matt Shardlow of the charity Buglife. "The scientific process appears to have been deliberately manipulated to agree with the environment secretary's views."

HIV emergency

THE US state of Indiana declared a public health state of emergency last week. The reason? Sixteen times as many HIV cases have been reported so far in 2015 than the state normally sees in a whole year. The jump has been linked to intravenous drug use and shared needles.

"This is all hands on deck," state governor Mike Pence said at a press conference on Thursday, referring to the outbreak as an "epidemic". The emergency declaration allows the release of additional resources and tools to tackle the problem.

The epicentre is Scott County in south-east Indiana. As of 27 March, 81 cases of HIV had been reported, all of which have been connected to the injection of drugs. The county normally sees five cases a year.

Needle exchange programmes are illegal in Indiana. However, Pence, a vocal opponent, has announced that the law will be changed so that a 30-day programme can be initiated to stop the virus spreading further.

Germanwings crash

FORENSIC teams have isolated DNA from 78 of the passengers who were on the Germanwings flight that crashed in the Alps last week.

The search for the flight data recorder is ongoing – but there are fears it may have been destroyed.

Data from the cockpit voice recorder has led investigators to believe that co-pilot Andreas Lubitz deliberately crashed the plane after locking the captain out of the cockpit. The captain should have been able to get in using emergency codes, but Lubitz must have held an override switch to keep him out. He then set the plane to descend.

Reports of sick notes found at Lubitz's home indicate that he might have been hiding a mental health condition from his employers.

Several European airlines have now changed their rules to ensure there are always two crew members in the cabin. This "rule of two" is already in place in the US.

Late hadron collider

HUMANKIND'S quest to understand our universe will have to wait. The Large Hadron Collider's reboot has been held up by a short circuit in one of the vast machine's magnets, potentially delaying its second run by weeks.

"The LHC is cooled to just above absolute zero, so you can't reach in and pluck the offending object out"

The short circuit is thought to be caused by a small piece of metal lodged inside an auxiliary piece of equipment on one of the magnets used to contain the LHC's accelerated beams. "It's a piece of metallic waste," says Paul Collier, CERN's head of beams. "We've got to get rid of it, we can't power the circuit with this in place."

The LHC is cooled to just a few degrees above absolute zero, so simply reaching in and plucking the offending object out of the collider is problematic.

Collier's team is exploring two remote fixes. The LHC's magnets are cooled by liquid helium, so the helium could be turned into a gas and blown through the system to dislodge the metal.

The alternative fix is more dramatic. The material is acting like a fuse, so it may be possible to blow that fuse by overloading it with electric current, burning it up in the process.

REUTERS/GONZALO FUENTES

The crash site

IMAGINECHINA

Asia gets the green light

Green power surge

THE balance of power is shifting. Almost half of global investment in new electricity generation last year was in renewables. The green boom was fuelled by a hike in investment by developing countries, says a UN report.

Global investment in green energy rose 17 per cent, but developing countries saw a surge of 36 per cent.

China was the world's largest investor – at $83 billion, up 37 per cent on 2013 – extending its lead over the US. And Brazil, India and South Africa were all in the top 10 investors. Japan came third and the UK beat Germany to fourth place.

"The big spending was on solar power in Asia and wind turbines in the North Sea"

Europe, once the green pioneer, dominated only one sector – offshore wind. The big spending was on solar power in Asia and wind turbines in the North Sea.

In the US, the 103 gigawatts of electricity generating capacity added by renewables equalled that provided by the country's nuclear power plant reactors.

Excluding large hydro-plants, because they cause other environmental problems, 9.1 per cent of the world's electricity was generated using renewable sources in 2014, up from 8.5 per cent the previous year. This rise cut carbon dioxide emissions by an estimated 1.3 billion tonnes, says the report.

The fall in the price of green technology is fuelling investment in renewables, says the report's co-author Udo Steffens.

Meningitis B shot

MENINGITIS B? There's a shot for that. From September, all babies in the UK will receive vaccinations for meningitis B, making the UK the first country to have a nationwide vaccine programme for the disease.

Meningitis B accounts for 60 to 80 per cent of the UK's meningitis cases. A tenth prove fatal and another tenth result in serious impairments like brain damage. Vaccines are already available for less common forms, such as meningitis C.

Sold as Bexsero, the vaccine will be made available through a deal between the UK Department of Health and GlaxoSmithKline, who bought the vaccine from its developer, Novartis. Bexsero was approved two months ago in the US for people aged between 10 and 25. It has previously been used following meningitis outbreaks at US universities.

60 SECONDS

Body-age predictor

My sagging eyes and flabby cheeks don't lie. A 3D imaging system can tell from your face whether your biological age – how your body has fared against the ravages of time – is out of whack with your chronological age. The system could shock people into changing their bad habits (*Cell Research*, DOI: 10.1038/cr.2015.36).

Lights on for graphene

Bulbs that contain graphene are to become the first commercial product from the UK that uses the wonder material. The bulbs have graphene-coated filaments to make them more conductive and energy-efficient.

Mean migration

One of the longest non-stop flights for a songbird has been recorded. Tiny geolocators were attached to blackpoll warblers as they migrated between North and South America. The birds flew 2770 kilometres over the Atlantic Ocean without stopping. It has been called "one of the most extraordinary migratory feats on the planet" (*Royal Society Letters*, DOI: 10.1098/rsbl.2014.1045).

Take heart

UK surgeons have performed Europe's first non-beating heart transplant. Donor hearts usually come beating from people who are brain dead. A new technique allows surgeons to restart a donated heart after it has ceased working and keep it alive outside of the body. This could increase heart transplants by 25 per cent in the UK alone.

Fish bounce back

Banning fishing in certain areas helps fish recover from climate events. When a tropical cyclone swept through the Great Barrier Reef Marine Park in 2009, the biomass of coral trout declined outside, but not inside, the protected reserves. Fish inside the reserves are bigger, and so able to spawn more larvae (*Current Biology*, DOI: 10.1016/j.cub.2015.01.073).

Cosmic radio plays an alien tune

Mysterious flashes show a strange regularity. **Sarah Scoles** investigates what they might be

ROGER RESSMEYER/CORBIS

The Parkes telescope: tuned in

BURSTS of radio waves flashing across the sky seem to follow a mathematical pattern. If the pattern is real, either some strange celestial physics is going on, or the bursts are artificial, produced by human – or alien – technology.

Telescopes have been picking up so-called fast radio bursts (FRBs) since 2001. They last just a few milliseconds and erupt with about as much energy as the sun releases in a month. Ten have been detected so far, most recently in 2014, when the Parkes Telescope in New South Wales, Australia, caught a burst in action for the first time. The others were found by sifting through data after the bursts had arrived at Earth. No one knows what causes them, but the brevity of the bursts means their source has to be small – hundreds of kilometres across at most – so they can't be from ordinary stars. And they seem to come from far outside the galaxy.

The weird part is that they all fit a pattern that doesn't match what we know about cosmic physics.

To calculate how far the bursts have come, astronomers use a concept called the dispersion measure. Each burst covers a range of radio frequencies, as if the whole FM band were playing the same song. But electrons in

"Perhaps extraterrestrial civilisations are flagging us down with basic multiplication"

space scatter and delay the radiation, so that higher frequency waves make it across space faster than lower frequency waves. The more space the signal crosses, the bigger the difference, or dispersion measure, between the arrival time of high and low frequencies – and the further the signal has travelled.

Michael Hippke of the Institute for Data Analysis in Neukirchen-Vluyn, Germany, and John Learned at the University of

Hawaii in Manoa found that all 10 bursts' dispersion measures are multiples of a single number: 187.5 (see chart, below). This neat line-up, if taken at face value, would imply five sources for the bursts all at regularly spaced distances from Earth, billions of light-years away. A more likely explanation, Hippke and Lerned say, is that the FRBs all come from somewhere much closer to home, from a group of objects within the Milky Way that naturally emit shorter-frequency radio waves after higher-frequency ones, with a delay that is a multiple of 187.5 (arxiv.org/abs/1503.05245).

They claim there is a 5 in 10,000 probability that the line-up is coincidence. "If the pattern is real," says Learned, "it is very, very hard to explain."

Cosmic objects might, by some natural but unknown process, produce dispersions in regular steps. Small, dense remnant stars called pulsars are known to emit bursts of radio waves, though not in regular arrangements or with as much power as FRBs. But maybe superdense stars are mathematical oddities because of underlying physics we don't understand.

It's also possible that the telescopes are picking up evidence of human technology, like an unmapped spy satellite, masquerading as signals from deep space.

The most tantalising possibility is that the source of the bursts might be a who, not a what. If none of the natural explanations pan out, their paper concludes, "An artificial source (human or non-human) must be considered."

"Beacon from extraterrestrials" has always been on the list of weird possible origins for these bursts. "These have been intriguing as an engineered signal, or evidence of extraterrestrial technology, since the first was discovered," says Jill Tarter, former director of the SETI Institute in California. "I'm intrigued. Stay tuned."

Astronomers have long speculated that a mathematically clever message – broadcasts encoded with pi, or flashes that count out prime numbers, as sent by aliens in the film *Contact* – could give away aliens' existence. Perhaps extraterrestrial civilisations are flagging us down with basic multiplication.

Power source

But a fast radio burst is definitely not the easiest message aliens could send. As Maura McLaughlin of West Virginia University, who was part of the first FRB discovery points out, it takes a lot of energy to make a signal that spreads across lots of frequencies, instead of just a narrow one like a radio station. And if the bursts come from outside the galaxy, they would have to be incredibly energetic to get this far.

If the bursts actually come from inside the Milky Way, they need not be so energetic (just like a nearby flashlight can light up the ground but a distant light does not). Either way, though, it would require a lot of power. In fact, the aliens would have to be from what SETI scientists call a Kardashev Type II civilisation (see "Keeping up with the Kardashevs", above).

But maybe there's no pattern at all, let alone one that aliens embedded. There are only 10 bursts, and they fit into just five groups. "It's very easy to find patterns when you have small-number statistics," says McLaughlin. "On the other hand, I don't think you can argue with the statistics, so it is odd."

The pattern might disappear as more FRBs are detected. Hippke and Learned plan to check their finding against new discoveries, and perhaps learn something about the universe. "Science is the best game around," says Learned. "You don't know what the rules are, or if you can win. This is science in action."

If the result holds up, says Hippke, "there is something really interesting we need to understand. This will either be new physics, like a new kind of pulsar, or, in the end, if we can exclude everything else, an ET."

Hippke is cautious, but notes that remote possibilities are still possibilities. "When you set out to search for something new," he says, "you might find something unexpected." ■

KEEPING UP WITH THE KARDASHEVS

THE first search for extraterrestrial intelligence, Frank Drake's Project Ozma, looked for radio broadcasts from hypothetical aliens in the 1960s.

Around the same time, cosmologist Nikolai Kardashev began to wonder what a truly advanced civilisation's radio messages might be like. His main conclusion: more powerful than ours. In a 1963 paper called "Transmission of Information by Extraterrestrial Civilizations", he grouped ETs into three categories according to how big their broadcasts could be. The labels stuck, and SETI scientists still use them today.

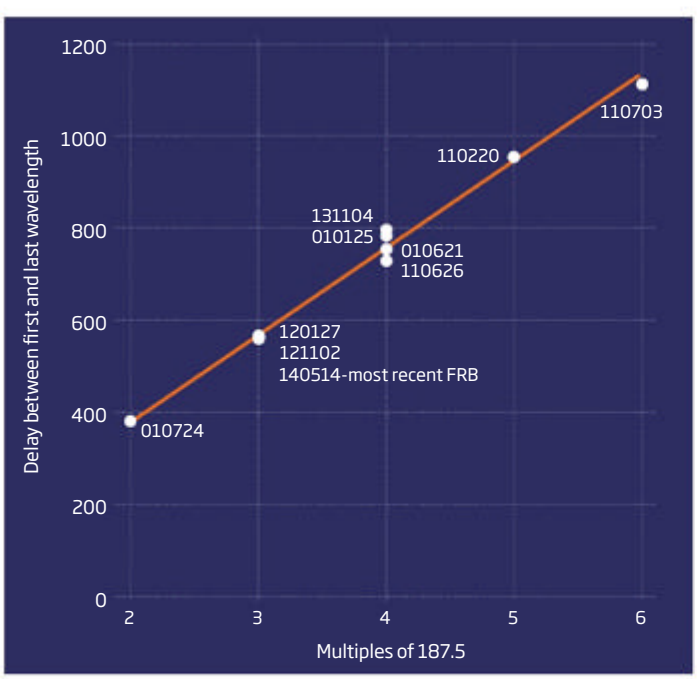
A signal from a Kardashev Type I society uses a planet's worth of energy, pulling from all its resources – solar, thermal, volcanic, tectonic, hydrodynamic, oceanic, and so on.

A Type II civilisation has a star's worth of output at its disposal. It would have to capture all its sun's radiation, throw material into a black hole and suck up the radiation, or travel to many planets and strip them of resources.

A Kardashev Type III civilisation controls the power output of a galaxy like the Milky Way. If a galaxy was home to just one Type III society, it would be completely dark except for the waste infrared radiation (heat) blowing from their massive engineering projects.

Signs of contact?

We have detected 10 fast bursts of radio waves (FRBs) coming from space in the past 15 years. The delay between the arrival of the first and last waves of each burst is always close to a multiple of 187.5. No known natural process can explain this



SUE FLOOD/GETTY

Struggling to take the strain

Antarctic ice is fading ever faster

Michael Slezak

IT'S melting from above and below and crumbling at the edges. Antarctica is in trouble. Its frozen edges, or ice shelves, are disappearing into the ocean faster than we thought. Some have thinned by up to 18 per cent in the past two decades, and the process is accelerating. The most rapidly melting ones are likely to be gone within a century.

As this happens, the ice sheets sitting over Antarctica's land – which hold the equivalent of 60 metres of sea level – will speed up their descent into the ocean, causing it to rise globally.

These new findings are the culmination of a torrent of studies over the past few years that have boosted our understanding of what is happening to Antarctica. And it's rarely been good news.

There is still a lot of uncertainty over how ice sheets will respond to climate change, which confounds our ability to predict sea level rises, says Fernando Paolo from the University of California, San Diego. That realisation has led to an explosion of research on the topic, he adds.

As for the ice shelves, their melting does not directly raise sea levels because they are already floating on the ocean. But they act like the crust at the edges of a lemon tart, preventing the filling from seeping outwards. In the case of Antarctica, the filling corresponds to the ice sheets, which will flow into the ocean and cause sea level rise once the ice shelves are gone.

Already, the loss of ice shelves in West Antarctica has led to a 59 per cent increase in ice discharge from some regions.

So far, the rate at which the ice shelves are melting has been a matter of debate, one confused by a plethora of satellite observations that cover short periods of time.

Paolo and colleagues have developed a model that combines data from three satellite missions, so that they could look at all the ice shelves over a period of 18 years. This allowed them to produce the first continuous plot of how the ice volume of the whole system was evolving (*Science*, doi.org/278).

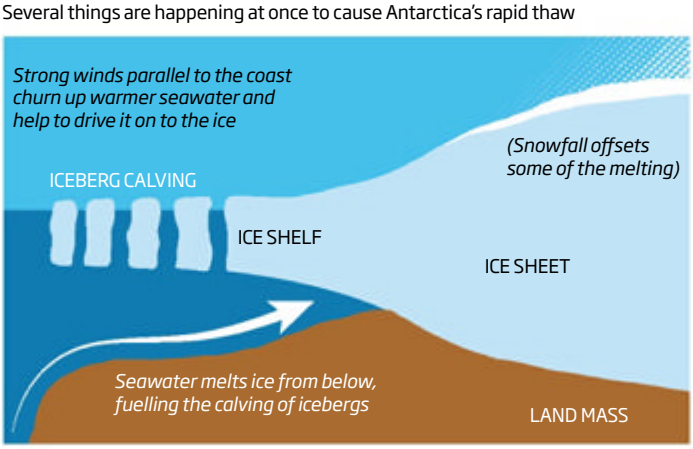
"We show not only that the total ice shelf volume is decreasing, but we see an acceleration in the last decade," says Paolo.

"We are seeing large changes over the course of decades. Some of these ice shelves could disappear"

For the first nine years of the study, the average thinning of the ice shelves across Antarctica was negligible. Consistent losses in vulnerable West Antarctica were

Ice under threat

Several things are happening at once to cause Antarctica's rapid thaw



mostly offset by gains in East Antarctica, which Paolo says might be a result of increased snowfall there – itself something that is forecast to happen as the globe warms.

But the second half of the study, covering 2003 to 2012, was completely different. Ice shelf loss off West Antarctica increased by 70 per cent over the previous nine years, and even East Antarctica showed a small loss, too. On average, some 310 cubic kilometres of ice was lost from the ice shelves each year during this time, and the process sped up as it went along.

"The fact that the rate of their thinning is increasing is alarming," says Ben Galton-Fenzi from the Australian government's Antarctic Division in Kingston.

The accelerating ice shelf loss in West Antarctica is mostly down to warmer water flowing underneath, says Paolo. That is happening because the sea surrounding Antarctica is warming, and the winds that push it against the ice are getting stronger (see diagram, left).

Changes in East Antarctica are harder to understand because we have less data for that region, says Paolo. More snowfall in the first nine years of the study might have masked any thinning, he says, but the factors that are melting West Antarctica could be starting to play a role in East Antarctica too.

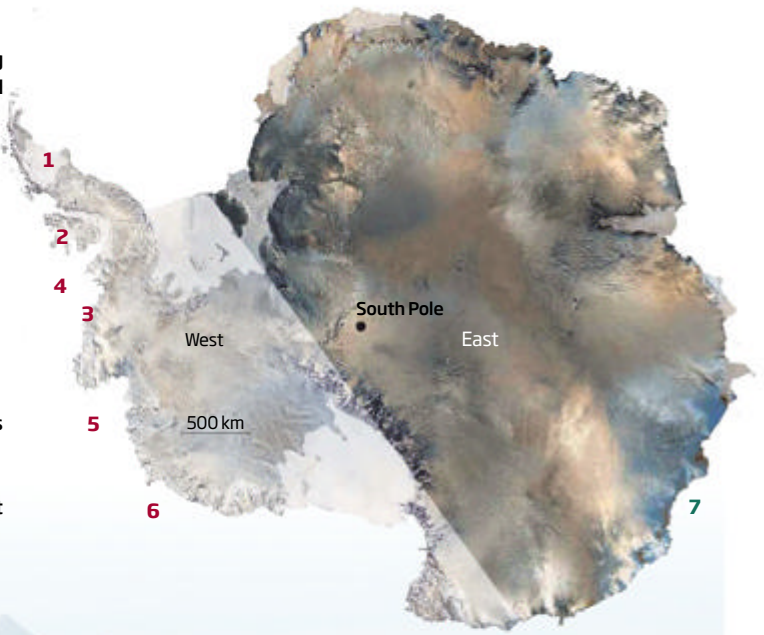
Some of the disappearing ice shelves are especially important for holding back the ice sheets. In particular, ice shelves in the Amundsen Sea, which regulate a lot of West Antarctica's ice, lost 8 per cent of their volume on average over the 18 years of the study.

Instead of taking hundreds of years to respond to warming, ice shelves will respond in a matter of years, according to Paolo. "We are seeing large changes over the course of decades," he says. "At current rates of change, some of these ice shelves could disappear within 100 years." ■

EAST VERSUS WEST

Some parts of Antarctica are melting much faster than others, as revealed by Fernando Paolo from the University of California, San Diego, and his colleagues, who looked at ice loss between 1994 and 2012 (see main story). Some ice shelves collapsed during this time, and now others are in danger of melting fast. West Antarctica has fared worse so far, but Paolo's study hints that the East may start catching up.

Ben Horton from Rutgers University in New Jersey says that as West Antarctica loses mass, sea levels will rise unevenly, with North Atlantic coastlines bearing the brunt of it. This means that coastal cities like New York will be worst affected.



WEST ANTARCTICA CRUMBLES

This part of Antarctica has been warming quickly. If the ice held here melted completely, it would raise sea level by more than 3 metres. Some studies suggest that the complete collapse of glaciers within the next 200 to 1000 years is now inevitable. The Antarctic peninsula, which juts towards South America, could be most affected: it has seen some of the fastest warming in the world, of about 2.5 °C over the past 50 years.

1 The Larsen collapses
Once there were three connected Larsen ice shelves on the Antarctic peninsula. Larsen A collapsed in 1995, Larson B in 2002 and Larsen C is at risk. Paolo's study shows that it is thinning and could separate from the continent within 100 years, if the current rate of loss persists.

2 The southernmost collapse
In 2009, the Wilkins ice shelf all but completely collapsed. It does not hold in any ice sheet, so the event will not contribute to sea level rise, but the collapse was significant as it was the closest yet to the South Pole.

3 Crosson and Venable ice shelves
Each of these has lost some 18 per cent of its thickness over the 18 years of the study, and could disappear within the next 100 years.

4 Bellingshausen Sea
Ice shelves in the Bellingshausen Sea have thinned at more than 7 metres per decade.

5 Amundsen Sea
Ice shelves in the Amundsen Sea have been thinning at almost 20 metres per decade. This, together with melting in the Bellingshausen Sea, accounts for 85 per cent of West Antarctica's ice loss over the study period. The Amundsen shelves matter as they are slowing the flow of some major glaciers.

6 Getz ice shelf
Part of the Amundsea Sea, Getz has thinned by a whopping 66.5 metres per decade, losing some 6 per cent of its volume over the 18 years of the study. It alone accounts for 30 per cent of the ice volume lost from West Antarctica.

EAST ANTARCTICA CLINGS ON

East Antarctica, facing the Indian Ocean, has experienced some of the slowest warming on Earth. That's fortunate, because it makes up two-thirds of Antarctica and holds most of the continent's ice. But not everything is hunky-dory.

7 Mixed news from Totten
Totten glacier drains ice from a huge part of East Antarctica, dumping about 70 billion tonnes of ice into the ocean each year, which is roughly on par with the amount of snowfall, keeping things in balance. The ice locked up in this glacier alone is equivalent to about 3.5 metres' worth of sea level. Earlier studies had suggested that the adjoining ice shelves could be thinning (*Nature*, doi.org/27v) although the Paolo study did not find any thinning in the 18 years to 2012. But this month it emerged that a tunnel under the ice shelf may be letting warm water reach the glacier (*Nature Geoscience*, doi.org/27w). That could be increasing the flow of the glacier and hence sea level rise.

FRANK KRAHMER/GETTY

HENNING DALHOFF/GETTY

How will the universe end?

Dark energy, the harbinger of doom

Maggie McKee

TALK about a cure that's worse than the disease. A proposed quantum field can account for the universe's ever-quickening expansion, but it would also trigger the universe's death in a catastrophic collapse.

In 1998, astronomers discovered that the universe has been ballooning at ever-faster rates for the past few billion years. They dubbed the mysterious entity responsible "dark energy" and have been striving to identify it ever since.

The simplest explanation is that particles briefly bubbling into and out of existence imbue every cupful of space with the energy needed to accelerate the universe's growth. But this quantum stew, known as vacuum energy, is no panacea.

Energy, like matter, causes space to curve, according to Einstein's general theory of relativity. Calculations suggest that this vacuum energy is so strong that it would make the universe curve in on itself until it spans less than the distance from Earth to the moon – and clearly it's bigger.

To get around this discrepancy, Nemanja Kaloper of the University of California, Davis, and Antonio Padilla of the University of Nottingham in the UK attempted to cancel out the curvature caused by the quantum instabilities by modifying the equations of general relativity

"Cosmic expansion must eventually reverse… the universe returns back to where it banged from"

on the largest scale possible: the whole of space-time.

Last year, they found a way to do this that cancels out nearly all of the vacuum energy, leaving just enough to explain the acceleration we observe (*Physical Review Letters*, doi.org/273). But their method requires space-time to be finite, which implies that cosmic expansion must eventually stop and reverse, causing time to end when the universe collapses. "The universe returns back to where it banged from," says Kaloper.

Now the researchers have proposed a trigger for that collapse: a new quantum field that permeates the universe. The field's energy would drop slowly over time, eventually becoming negative and setting off the cosmos's contraction. Before the contraction begins, however, the field would cause the universe's initial expansion to accelerate, just as it is doing now. "It's as if the dark energy is the harbinger of doom," says Padilla (*Physical Review Letters*, doi.org/274).

"It's an interesting approach, but it's still incomplete," says Asimina Arvanitaki of the Perimeter Institute in Waterloo, Canada. "What is the underlying theory that tells you that this is how you should write down your equations?"

The researchers are now working on a generalisation of their proposal that should help address these concerns, says Kaloper. They are also calculating when the universe's contraction may begin, though they suspect it wouldn't start for another few tens of billions of years, says Padilla.

"We're pretty safe," says Arvanitaki. "I'm not going to lose any sleep over it." ■

If drugs don't work, convert the cancer

YOU can't kill the beast, but perhaps soothing it will work. Rather than attacking hard-to-treat tumours directly, it might be possible to transform them. That is the possibility raised by the discovery of a genetic switch that may turn the fiercest breast cancer into a relative pussycat.

To grow, about 85 per cent of breast cancer tumours need the hormones progesterone or oestrogen, or a protein called HER2. That usually makes treatment simple: block those chemicals and you halt the cancer.

But the other 15 per cent are called triple negative breast cancers, because they don't need any of the three chemicals and thus resist such treatments. Up to half of people with triple negative cancer die within five years of diagnosis.

Now a team led by Alex Swarbrick from the Garvan Institute of Medical Research in Sydney, Australia, may have hit on a way of making triple negative cancer toe the line.

The team analysed the DNA of 80 women with triple negative cancer, and found that their tumours produced a lot of a protein called ID4. So, in mice, the team blocked the *ID4* gene producing the protein. Their tumours stopped growing and other cancer-related genes got switched on or off. Genes present in cancers that respond to oestrogen treatment were activated, making aggressive, resistant breast cancer look like one of the easiest to treat (*Nature Communications*, doi.org/27z).

"Maybe we can shift the tumour in the direction of the therapy rather than developing the therapy in the direction of the tumour," says Rob Ramsay from the Peter MacCallum Cancer Centre in Melbourne, Australia.

Other genes also play a role in whether a tumour is susceptible to a therapy, so this might not be the whole story. Swarbrick's team is now looking to see if the switched tumours respond to the oestrogen-related drug, tamoxifen. Michael Slezak ■

GET INSIDE YOUR OWN HEAD

The Human Brain uncovers everything you need to know about the most complex object in the known universe

Buy your copy now from all good newsagents or digitally. Find out more at **newscientist.com/thecollection**

NewScientist

Anglo-Saxon recipe vanquishes MRSA

Clare Wilson

TAKE cropleek and garlic, of both equal quantities, pound them well together… take wine and bullocks gall, mix with the leek… let it stand nine days in the brass vessel…

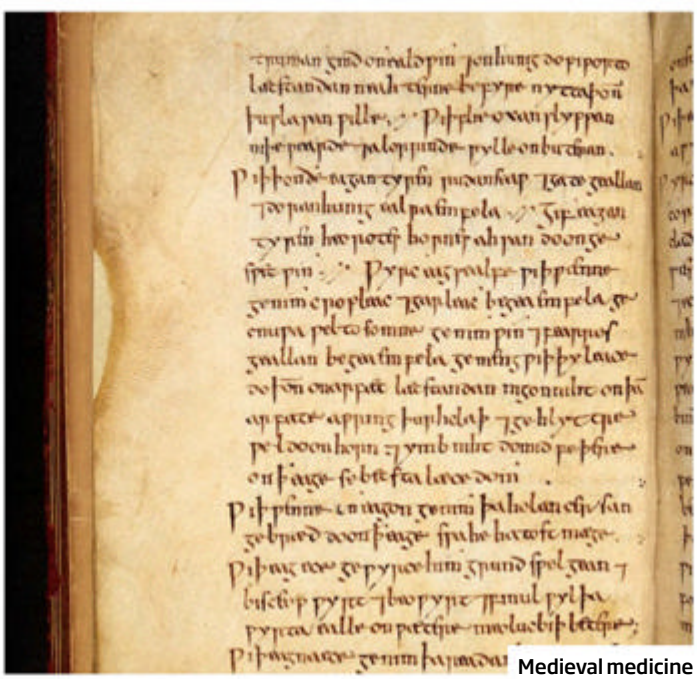
So goes a 1000-year-old Anglo-Saxon remedy for treating a stye, an infected eyelash follicle. The medieval medics may have been on to something. A modern-day recreation seems to alleviate infections caused by the bacteria responsible for styes. The work might ultimately help create drugs for hard-to-treat skin infections.

The project started when Freya Harrison, a microbiologist at the University of Nottingham, UK, got talking to Christina Lee, an Anglo-Saxon scholar. They decided to test a recipe from an Old English medical compendium called *Bald's Leechbook*. Some of the ingredients, such as copper from the brass vessel, are known to kill bacteria grown in a dish, but it was unclear if they would work on a real infection.

Sourcing authentic ingredients was a major challenge, says Harrison. They had to hope for the best with the leeks and garlic because modern crop varieties are likely to be quite different from ancient ones. They used an organic wine from a historic English vineyard.

As "brass vessels" would be impractical to sterilise – and expensive – they used glass bottles with squares of brass sheet immersed in the mixture. Bullocks gall was easy, though, as cow's bile salts are sold as a supplement for people who have had their gall bladders removed.

After nine days of stewing, the potion had killed all the soil bacteria introduced by the leek and garlic. "That was the first inkling that this crazy idea just might have some use," says Harrison, who presented the research at the Society for General Microbiology conference in Birmingham, UK, this week.



THE BRITISH LIBRARY BOARD (ROYAL 12 D XVII)

Medieval medicine

The potion was tested on scraps of skin taken from mice infected with methicillin-resistant *Staphylococcus aureus*. This is more commonly known as the hospital superbug MRSA, an antibiotic-resistant version of the bacterium that causes styes. The potion killed 90 per cent of the bacteria. Vancomycin, the antibiotic used to treat MRSA, killed about the same proportion when it was added to the mix.

Unexpectedly, the ingredients had little effect unless they were all brought together. "The big challenge is trying to find out why that combination works," says Steve Diggle, another of the researchers. Do the components work in synergy or do they form new potent compounds?

Using exactly the right method also seems to be crucial; another group tried to recreate the remedy in 2005 and found that their potion failed to kill bacteria. "With the nine-day waiting period, the preparation turned into a kind of loathsome, odorous slime," says Michael Drout of Wheaton College in Norton, Massachusetts.

If the 9th-century recipe does lead to new drugs, they might be useful against MRSA skin infections such as those that cause foot ulcers in people with diabetes. "These are usually antibiotic-resistant," says Diggle. However, he doesn't recommend people try the recipe at home. ■

Croc and awe as tiny ants devour young caimans

THIS puts the story of David and Goliath into perspective. Tiny red fire ants in Argentina target fearsome caimans, with as many as one in four of the crocodilian's babies falling prey to insect attackers.

The ants colonise more than half the broad-snouted caiman nests, where the fermenting bedding material provides the humidity and warmth the insects' eggs and larvae need.

They bite the caiman mum, forcing her to abandon the nest. Then, when the young start to hatch, the ants sneak inside the eggs to kill the babies and eat them. It seems that 26 per cent of broad-snouted caiman babies in a breeding season could die by red fire ant predation (*Journal of Herpetology*, doi.org/266).

The baby caimans are defenceless against an army of the little red monsters. "It is not one caiman against one red fire ant – it is one caiman against about 100,000 fire ants," says Carlos Ignacio Piña of the Laboratory of Applied Zoology in Santa Fe, Argentina, an author of the study. "There are so many fire ants that the baby caiman starts to shake like crazy, trying to get released."

The proportion of killed caimans is somewhat disturbing, but not crazily high, says Craig Allen from the University of Nebraska-Lincoln. It is of no immediate concern to caiman populations in South America because the ants and caimans co-evolved there, and natural red fire ant predators, such as the decapitating fly, help keep the ants in check.

"It is not one caiman against one red fire ant – it is one caiman against 100,000 fire ants"

Elsewhere though, these invasive ants could wreak havoc, partially because their natural predators are absent. Allen has previously found that they can kill 70 per cent of turtle hatchlings in Florida. In the US, they have also been caught munching on snakes, lizards, birds and even deer fawns, who freeze when in danger, giving ants time to attack. Agata Blaszczak-Boxe ■

CHRIS FALLOWS

Seal turns tables on sharks to feast on their intestines

THAT shark's fate is sealed. A seal has been spotted turning ecological roles upside-down by killing and eating blue sharks. If this turnabout proves common, ecologists might need to reassess the role of seals in marine ecosystems.

Chris Fallows, a dive-boat operator in Cape Town, South Africa, was photographing 10 blue sharks underwater when a young male Cape fur seal arrived and chased and killed five of them, eating their intestines (*African Journal of Marine Science*, doi.org/268).

Ordinarily, seals and blue sharks, which are roughly the same size, both prey on much smaller fish, squid and other marine life. Several species of seal also feed on smaller sharks, and blue sharks have been seen pursuing – though not catching – fur seals.

Fallows's observations are the first time anyone has seen seals preying on such large sharks, says Hugues Benoit of the Canadian Department of Fisheries and Oceans in Moncton, New Brunswick.

Benoit suspects this behaviour is more common than anyone realises. By chowing down on their competitors, seals could alter ocean food webs in unexpected ways, he says. If seals help hold down shark populations, for example, it could boost populations of smaller fish.

If so, fisheries biologists may need to take that into account in managing fish populations.

Big bank balance begets brainy babies

HAVE Mum and Dad got a few quid to spare? You'd better hope so because the wealthier your parents, the larger the surface area of your brain, something that is linked with higher intelligence.

We know that factors such as a parent's job, education and income correlate with a child's intelligence but the cause isn't clear. A team led by Elizabeth Sowell at the Children's Hospital Los Angeles used MRI scans to look at the brain structure of more than a thousand 3 to 20-year-olds.

Parental income and education were both linked to their brain surface area. The size increase was largest in areas related to reading, language and spatial skills. The team then gave the children cognitive tests and found that, as expected, those from wealthier backgrounds did better.

Statistical models given both sets of data suggested that brain surface area could partially account for the link between test performance and income.

This is the largest study yet to connect socio-economic status and brain structure, but the mechanism that links them is unclear and the results do not suggest a child's fate is cast in stone, says Sowell (*Nature Neuroscience*, DOI: 10.1038/nn.3983).

Spacecraft scorch marks fade away

WE'VE been making a mess on Mars, but the Red Planet tidies up after us. A study of the scorch marks left by the Curiosity rover and Phoenix lander as they touched down on Mars has revealed that they fade over time.

Ingrid Daubar of NASA's Jet Propulsion Laboratory in California and her colleagues gathered images of the Curiosity and Phoenix landing sites taken by the Mars Reconnaissance Orbiter over a number of years.

By measuring the relative amount of light reflected by the scorch marks and pristine soil in each picture, Dauber calculated that it should take 2.6 Earth years for them to disappear completely. That could be important for NASA's next lander, the InSight mission, which will study heat flow on the planet's surface. The work was presented at the Lunar and Planetary Science Conference in The Woodlands, Texas, last week.

Dusty tale of moon's second tail

DID you know that the moon has a tail? Turns out, it has two.

Data from NASA's Lunar Atmosphere and Dust Environment Explorer (LADEE), which spent seven months orbiting the moon in 2013 and 2014, has revealed a tail of nanoscale dust particles.

The finding follows the discovery of the first lunar tail in 1999, when ground-based telescopes spotted a faint stream of sodium gas stretching out behind the moon.

Anthony Colaprete, who leads LADEE's spectrometer instrument, thinks the second tail is the result of dust particles thrown up when asteroids crash into the surface and are pushed away by the sun's radiation pressure.

Giant pandas are sociable after all

EVERYONE needs friends. Even giant pandas. Researchers spying on the species in the wild have found that they are more sociable than we thought, hanging out together for weeks at a time.

We know very little about wild pandas because they are so rare and live in almost impenetrable forest. But in 2010 and 2011, Vanessa Hull of Michigan State University and her colleagues were given permission to attach GPS tracking collars to five pandas in the Wolong Nature Reserve in China. The collars transmitted each animal's position every four hours, for up to two years.

The team found that the home ranges of individual pandas overlapped and, on a few occasions, two animals spent several weeks in close proximity (*Journal of Mammalogy*, DOI: 10.1093/jmamma/gyu031). "Sometimes the pandas were within 10 or 20 metres of each other, which suggests the pandas were in direct interaction," Hull says. This happened in autumn, and pandas mate in spring, so it was probably not mating behaviour.

The team also found that pandas rotated between several core areas, probably following patches of bamboo, their only food source. "They kind of eat their way out of the bamboo, and when it's depleted they move on," says Hull.

JUAN CARLOS MUNOZ/BIOSPHOTO/FLPA

Charge of the magnetite brigade – bugs power up on minerals

IS THIS the world's smallest power station? Bacteria have been found growing on tiny magnetic particles, which they use as natural rechargeable batteries.

Electric bacteria have become a hot topic, with the discovery that some bacteria found beneath seabeds and riverbeds can harvest energy in the shape of electrons gathered from tiny metallic particles.

Bacteria can also dump electrons onto different metals. This cycle of harvesting and dumping electrons is essential for powering life, and in animals is done by eating food and breathing oxygen.

Now James Byrne of the University of Tübingen in Germany and his team have found that tiny crystals of magnetite, a common magnetic mineral, can be used as both electron acceptors and electron donors for the bacteria, working like a battery.

He grew mixed colonies of *Geobacter* and *Rhodopseudomonas* bacteria on magnetite and found that magnetite gave electrons to *Rhodopseudomonas* and accepted them from *Geobacter* (*Science*, doi.org/28f). In the wild, Byrne says, the two reactions probably happen during day and night cycles or tide phases, with each type of bacteria active at different times. The magnetite crystals, he says, act like rechargeable batteries.

Lars Peter Nielsen of Aarhus University in Denmark says the discovery shows how magnetite can serve as a conductor, sink and source of electrons, depending on the needs of the microbes.

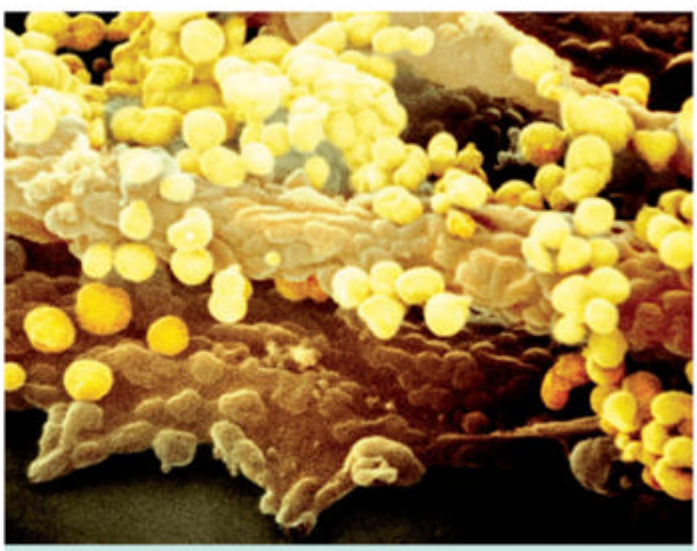
Dark matter's a loner, galaxies say

DARK matter is so antisocial, it won't even talk to itself. New measurements of collisions between dozens of galaxy clusters show that the mysterious stuff is even more ghostly than imagined.

Dark matter is thought to make up 83 per cent of the matter in the universe, but scientists are unsure exactly what it is. Observations of collisions between galaxy clusters show that it refuses to interact with ordinary matter except through gravity: when two clusters collide, their galaxies glide past each other and leave a trail of gas behind. The dark matter, seen indirectly by its gravitational effects, remains with the galaxies.

Some studies have hinted that dark matter might interact with itself via a new force. To test this idea, David Harvey of the Swiss Federal Institute of Technology in Lausanne and his colleagues looked at the positions of gas, galaxies and dark matter in 30 colliding clusters (*Science*, doi.org/28g).

They found that the dark matter carries on its path unimpeded by any other dark matter around, suggesting that it doesn't interact with itself after all.



NIBSC/SCIENCE PHOTO LIBRARY

Faulty genes can give us deadly flu

WHAT makes the same flu virus kill some people, while others can just take a duvet day? A French girl has provided part of the answer.

The girl nearly died of flu in 2011, aged only 2, but had none of the conditions that normally make the virus worse. Now partial sequencing of her and her parents' genomes has revealed the role her genes played.

We all have two copies of a gene that helps boost the production of interferon, a virus-fighting molecule. Each parent had one normal copy of the gene, but both had mutations in the other. Their daughter inherited a defective copy from each parent, leaving her immune and lung cells unable to crank out interferon when exposed to flu (*Science*, doi.org/275).

"This was her first case of flu ever, she had no immunity from previous infections," says Jean-Laurent Casanova at the Imagine Institute of Genetic Diseases in Paris. "So the severity of the disease was all down to genetics." The girl has been flu-free since being vaccinated.

Casanova's team is now looking for other mutations in interferon-related genes in children who have had severe flu.

You are being replaced

People have talked about robots taking our jobs for ages. The problem is that they already are, we just haven't noticed, finds **Hal Hodson**

FORGET Skynet. Hypothetical world-ending artificial intelligence makes headlines, but the hype ignores what's happening right under our noses. Cheap, fast AI is already taking our jobs, we just haven't noticed.

This isn't dumb automation that can rapidly repeat identical tasks. It's software that can learn about and adapt to its environment, allowing it to do work that used to be the exclusive domain of humans, from customer services to answering legal queries.

These systems don't threaten to enslave humanity, but they do pose a challenge: if software that does the work of humans exists, what work will we do?

In the last three years, UK telecoms firm O2 has replaced 150 workers with a single piece of software. A large portion of O2's customer service is now automatic, says Wayne Butterfield, who works on improving O2's operations. "Sim swaps, porting mobile numbers, migrating from prepaid onto a contract, unlocking a phone from O2" – all are now automated, he says.

"The AI mimics a human. If you watch one working it looks a bit mad. You see it typing, cutting, pasting"

Humans used to manually move data between the relevant systems to complete these tasks, copying a phone number from one database to another, for instance. The user still has to call up and speak to a human, but now an AI does the actual work.

To train the AI, it watches and learns while humans do simple, repetitive database tasks. With enough training data, the AIs can then go to work on their own. "They navigate a virtual environment," says Jason Kingdon, chairman of Blue Prism, the start-up which developed O2's artificial workers. "They mimic a human. They do exactly what a human does. If you watch one of these things working it looks a bit mad. You see it typing. Screens pop-up, you see it cutting and pasting."

One of the world's largest banks, Barclays, has also dipped a toe into this specialised AI. It used Blue Prism to deal with the torrent of demands that poured in from its customers after UK regulators demanded that it pay back billions of pounds of mis-sold insurance. It would have been expensive to rely entirely on human labour to field the sudden flood of requests. Having software agents that could take some of the simpler claims meant Barclays could employ fewer people.

The back office work that Blue Prism automates is undeniably dull, but it's not the limit for AI's foray into office space. In January, Canadian start-up ROSS started using IBM's Watson supercomputer to automate a whole chunk of the legal research normally carried out by entry-level paralegals.

Legal research tools already exist, but they don't offer much more than keyword searches. This returns a list of documents that may or may not be relevant. Combing through these for the argument a lawyer needs to make a case can take days.

ROSS returns precise answers to specific legal questions, along with a citation, just like a human researcher would. It also includes its level of confidence in its answer. For now, it is focused on questions about Canadian law, but CEO Andrew Arruda says he plans for ROSS to digest the law around the world.

Since its artificial intelligence is focused narrowly on the law, ROSS's answers can be a little dry. Asked whether it's OK for 20 per cent of the directors present at a directors' meeting to be Canadian, it responds that no, that's not enough. Under Canadian law, no directors' meeting may go ahead with less than 25 per cent of the directors present being Canadian. ROSS's source? The Canada Business Corporations Act, which it scanned and understood in an instant to find the answer.

By eliminating legal drudge work, Arruda says that ROSS's automation will open up the market for lawyers, reducing the time they need to spend on each case. People who need a lawyer but cannot afford one would suddenly find

IZZY SCHWARTZ/GETTY

WHICH JOBS WILL GO NEXT?

Artificial intelligence is already on the brink of handling a number of human jobs (see main story). The next jobs to become human-free might be:

TAXI DRIVERS - Uber, Google and established car companies are all pouring money into machine vision and control research. It will be held back by legal and ethical issues, but once it starts, human drivers are likely to become obsolete.

TRANSCRIBERS - Every day hospitals all over the world fire off audio files to professional transcribers who understand the medical jargon doctors use. They transcribe the tape and send it back to the hospital as text. Other industries rely on transcription too, and slowly but surely, machine transcription is starting to catch up. A lot of this is driven by data on the human voice gathered in call centres.

FINANCIAL ANALYSTS - Kensho, based in Cambridge, Massachusetts, is using AI to instantly answer financial questions which can take human analysts hours or even days to answer. By digging into financial databases, the start-up can answer questions like: "Which stocks perform best in the days after a bank fails". Journalists at NBC can already use Kensho to answer questions about breaking news, replacing a human researcher.

No people needed

legal help within their means.

ROSS's searches are faster and broader than any human's. Arruda says this means it doesn't just get answers that a human would have had difficulty finding, it can search in places no human would have thought to look. "Lawyers can start crafting very insightful arguments that wouldn't have been achievable before," he says. Eventually, ROSS may become so good at answering specific kinds of legal question that it could handle simple cases on its own.

Where Blue Prism learns and adapts to the various software interfaces designed for humans working within large corporations, ROSS learns and adapts to the legal language that human lawyers use in courts and firms. It repurposes the natural language-processing abilities of IBM's Watson supercomputer to do this, scanning and analysing 10,000 pages of text every second before pulling out its best answers, ranked by confidence.

Lawyers are giving it feedback too, says Jimoh Ovbiagele, ROSS's chief technology officer. "ROSS is learning through experience."

Massachusetts-based Nuance Communications is building AIs that solve some of the same language problems as ROSS, but in a different part of the economy: medicine. In the US, after doctors and nurses type up case notes, another person uses those notes to try to match the description

"In the next few years everyone will be familiar with AI workers. They will be in every single office"

with one of thousands of billing codes for insurance purposes.

Nuance's language-focused AIs can now understand the typed notes, and figure out which billing code is a match. The system is already in use in a handful of US hospitals.

Kingdon doesn't shy away from the implications of his work: "This is aimed at being a replacement for a human, an automated person who knows how to do a task in much the same way that a colleague would."

But what will the world be like as we increasingly find ourselves working alongside AIs? David Autor, an economist at the Massachusetts Institute of Technology, says automation has tended to reduce drudgery in the past, and allowed people to do more interesting work.

"Old assembly line jobs were things like screwing caps on bottles," Autor says. "A lot of that stuff has been eliminated and that's good. Our working lives are safer and more interesting than they used to be."

Deeper inequality?

The potential problem with new kinds of automation like Blue Prism and ROSS is that they are starting to perform the kinds of jobs which can be the first rung on the corporate ladders, which could result in deepening inequality.

Autor remains optimistic about humanity's role in the future it is creating, but cautions that there's nothing to stop us engineering our own obsolescence, or that of a large swathe of workers that further splits rich from poor. "We've not seen widespread technological unemployment, but this time could be different," he says. "There's nothing that says it can't happen."

Kingdon says the changes are just beginning. "How far and fast? My prediction would be that in the next few years everyone will be familiar with this. It will be in every single office."

Once it reaches that scale, narrow, specialised AIs may start to offer something more, as their computation roots allow them to call upon more knowledge than human intelligence could.

"Right now ROSS has a year of experience," says Ovbiagele. "If 10,000 lawyers use ROSS for a year, that's 10,000 years of experience." ■

ONE PER CENT

STARTRAKS PHOTO/REX

15 swipes of fame

Fancy yourself as a future pop star? A new app called Chosen brings X-Factor-style talent shows to smartphones, letting anyone participate remotely. The app lets users vote on their fellow wannabe stars who upload videos of themselves performing. The winner will be announced in June, and get a chance to play on stage at the Bonnaroo music festival in Tennessee.

"You might consider closing your Facebook account, if you have one"

European Commission attorney **Bernhard Schima** warns that it may be impossible to stop US authorities accessing EU citizens' data in a hearing at the European court of justice in Luxembourg

Messages in games

Video games can hold more secrets than their designers had in mind. Researchers at Stonybrook University in New York have found a way to hide messages in the gameplay of a real-time strategy game called *Castle*. Messages are sent by encoding text as a series of commands, automatically sent into the game (arxiv.org/abs/1503.05904). The receiver decodes the message by analysing the summary in the game log.

Waste-pickers' tool pinpoints people with useful trash

EVEN rubbish is getting into the so-called gig economy. A website matches waste-pickers in Bangalore, India, with residents who need their trash taken away.

Waste-pickers earn a couple of dollars a day sorting through the city's overflowing landfills, looking for paper or plastic to sell to recycling centres. It's hard, dirty work, but it's estimated that 1.5 million people in India make their living this way.

I Got Garbage is an online tool designed to help waste-pickers better connect with households and offices that need their trash picked up. Those looking for trash collection sign up with their contact information, which is passed on to local groups of waste-pickers and non-profits that work with them. For pickers, the site also has a map of collection centres and the types of scrap they accept.

The site was started by Mindtree, an information technology firm based in Bangalore, in an effort to bolster the livelihood of local waste-pickers. The firm also hopes the programme will reduce India's excess garbage – a side effect of overcrowding and poor waste management practices.

Around the country, other groups are trying to support waste-pickers. For example, in Pune, a city in western India, pickers have formed a cooperative that officially works for the city government. Aviva Rutkin ■

DBIMAGES/ALAMY

Turning trash into treasure

FRANK KRAHMER/GETTY

Help is a tap away

App tells rescuers how to reach and save you

MICHAEL MARTIN slides his phone over to me. On the screen are four brightly coloured buttons labelled with calamities like "fire" and "car crash". I put my finger over one, then hesitate.

"Don't worry," he says. "It won't actually call 911."

Not yet, anyway. Martin is showing me the latest version of One-Touch-911, an app created by his start-up, RapidSOS. It reimagines how people get help in an emergency: rather than dialling a phone number, users can push a single button to summon first responders.

Emergency dispatch systems need an overhaul. They were designed to handle calls from landlines, automatically pulling up the name and address associated with the fixed line. But today, about 70 per cent of 911 calls in the US are from cellphones, and may not register a location or callback number in the system. The call can be traced to a nearby cellular tower, but that takes time and only gives a rough location. If someone can't speak because they are in danger or badly hurt, if they don't know where they are or the call gets cut off too soon, then calling from a mobile gives the police nothing to go on.

"People have at their fingertips the ability to push and pull data, to take pictures and video, to text," says Brian Fontes, CEO of the National Emergency Number Association in Alexandria, Virginia. "They're expecting the parties with whom they communicate to have these same capabilities."

"The call is tagged with the phone's GPS location and any medical details the user previously entered"

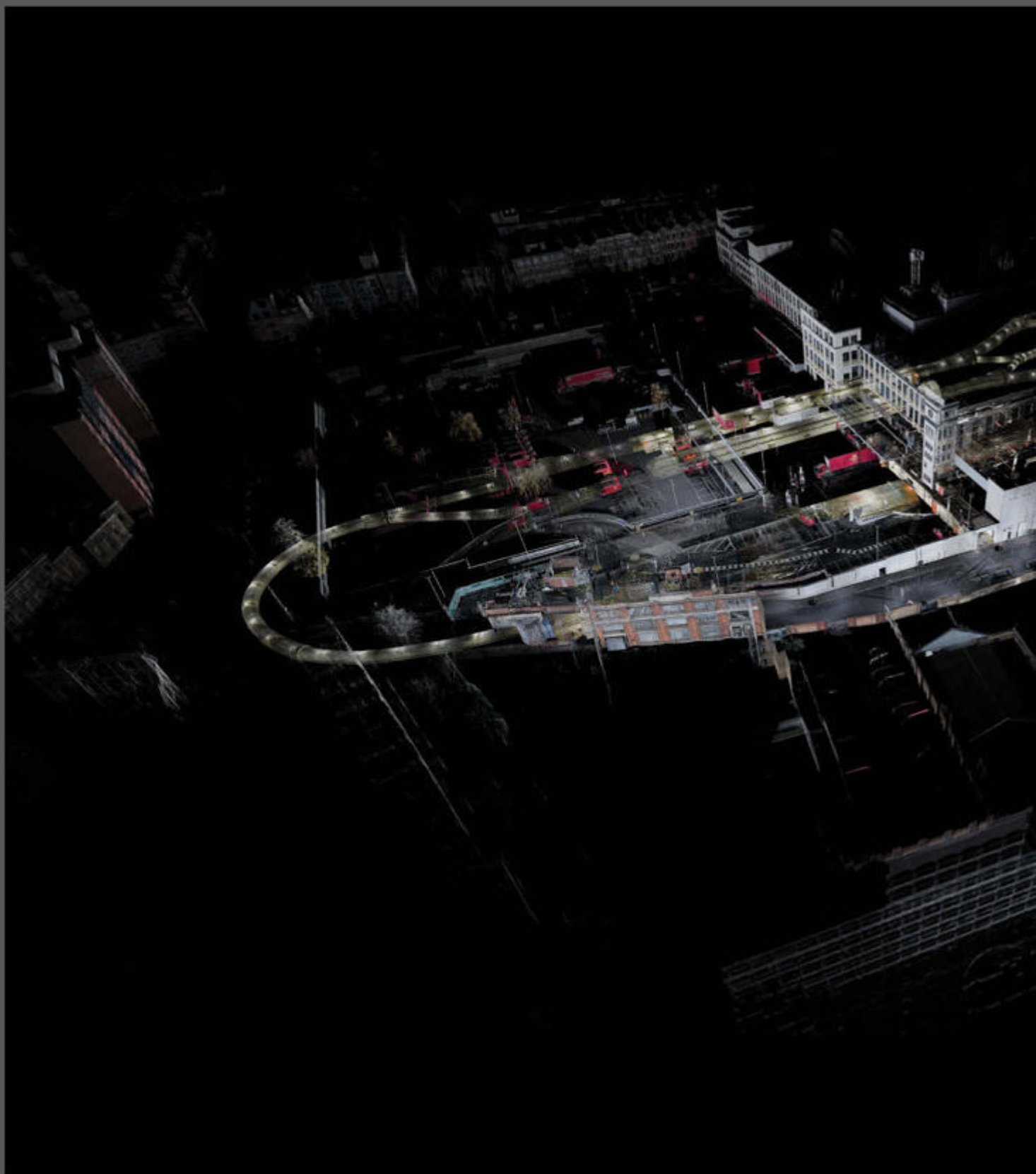
Based in Cambridge, Massachusetts, RapidSOS created One-Touch-911 to provide enough data for emergency services to respond. Each button in the app triggers a standard call to nearby dispatchers, but the call arrives tagged with the phone's GPS location and any medical details the user previously entered into the system. That's enough to send police or ambulances on their way, even if the person is unable to speak. Users can also set the app to notify friends or family members if a call goes out.

Where cellular coverage is limited, the app tries to find alternative routes for the call through Wi-Fi networks. It also focuses on getting richer information out than a simple phone call could: it is able to send pictures and video, although not all emergency dispatchers can receive them at present.

RapidSOS is launching a pilot programme in northern Texas in May, and has started a crowdfunding campaign to recruit testers. The firm needs to ensure that the app plays well with the many software systems used by dispatchers across the US.

Martin says some of this software is holding up progress. "I can push a button and call Uber, but I can't call a first responder," says Martin. "We thought, we should just build a really reliable version of that technology. But it's a challenge to drive innovation into the existing system." Aviva Rutkin ■


BIG LANDSCAPES
INSPIRE BIG THINKING
THERE'S NOTHING LIKE AUSTRALIA FOR YOUR NEXT BUSINESS EVENT.
This year we chose Australia for our global congress. It was an easy choice, as Australia's proximity to Asia gave us the opportunity to attract many new delegates. The program was one of the best in years. New Australian developments in our field attracted a lot of interest and strong international research partnerships were established.
Australia is on everyone's list to visit, and it lured our highest number of delegates yet. There's no doubt they'll be talking about this convention for years to come.
Dr Louise Wong,
International Board Member
VISIT
AUSTRALIA.COM/BUSINESSEVENTS/ASSOCIATIONS
FOR EVERYTHING YOU NEED TO PLAN YOUR AUSTRALIAN EVENT.
BUSINESS EVENTS
AUSTRALIA



Loco emotive

THE next Bond villain's lair? An alien spaceship lying dormant under an unsuspecting city?

This 3D scan of an underground structure is actually of something much more familiar: a postal service. The Mail Rail network shuttled mail around London for 76 years until being decommissioned in 2003. Now it has been frozen in time. This aerial view of the network is below a sorting station soon to be home to a postal museum – the loop of track will be a train ride whizzing visitors through a kilometre of tunnels.

The segment of the world's first driverless, electrified railway has remained untouched since the site shut down, strewn with personal items left behind by workers including dartboards, tools and calendars.

But since the site will be cleaned up before it opens to the public in 2016, digital scans will be the only record of its days as a working piece of infrastructure. To create the image, capturing details as small as 2 millimetres across, a camera-like device on a tripod emits a laser that bounces off objects in its path 250,000 times a second. The scanner needs to capture about four different perspectives to recreate a site, in a process that takes less than 30 minutes.

The 3D reconstructions could be used in an augmented reality app, allowing museum visitors to view original details of the site with a smartphone while strolling around.

Sandrine Ceurstemont

Photography

ScanLAB Projects

Above: Royal Mail courtesy of The British Postal Museum & Archives

We are what we vote

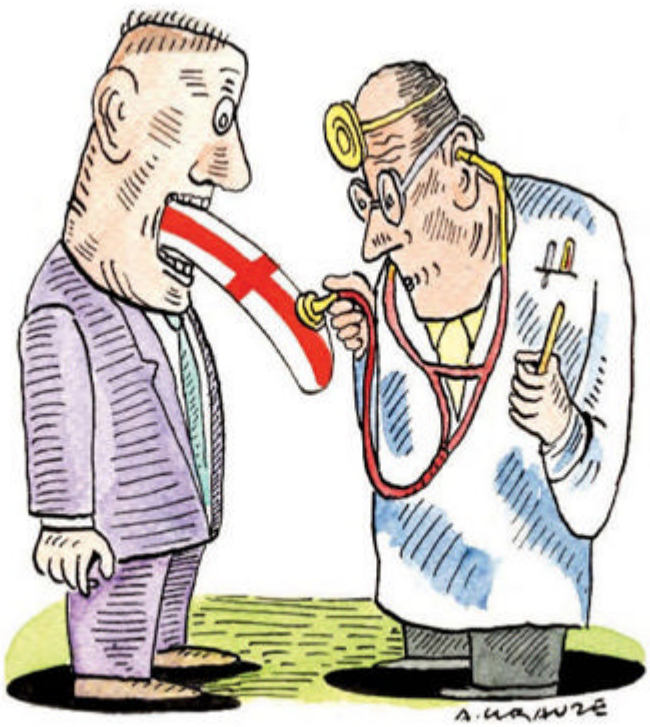
Examining our basic biological impulses can help to explain the attraction of populist politics, say **John Hibbing** and **Kevin Smith**

POPULIST movements are everywhere at the moment, on both the left and right of politics. Yet many observers seem in denial about the strength and stubborn appeal of this phenomenon and, rather than trying to explain it, simply dismiss it as irresponsible pandering to the masses.

At the same time, scholars are using biology to understand political attitudes, chiefly the liberal-conservative split. Might this approach help us understand populism's pull?

Populists are characterised not just by their championing of the interests of ordinary people, but also by their often angry crusades against political or economic entities seen as hostile and threatening to those interests. These can be external: the European Union fits that bill for the left-leaning Syriza party in Greece as well as for the right-leaning UKIP in the UK. They can be internal: elite corporations and an out-of-touch government have spurred both the right-leaning Tea Party and the left-leaning Occupy movement in the US. Similar forces are at work in Spain, where left-wing Podemos is riding high.

Arguably, the most potent and volatile populist catalyst is immigration. Political systems throughout Europe typically have at least one right-leaning populist party unsympathetic or openly hostile to immigrants. It is not unusual for them to draw 10 to 15 per cent of the vote, sometimes more. In January, polls suggested the anti-immigration National Front, led by Marine Le Pen, was the most popular party in France.



Research in the past few years, using information on brain structure and function from MRI scans, physiological responses, eye-trackers and behavioural genetics, shows that individual political orientations are deeply connected to biological forces that are usually beyond personal control (see page 28). Despite initial incredulity – people like to believe political opinions are rational responses to salient events – the evidence that political preferences are linked to systems that often involve subconscious processes is growing. An admittedly simplistic but useful summary of this research is that human emotions are grounded in biology, and politics is grounded in emotions.

When it comes to biology and populism, it is worth asking two questions: first, why does populist parties' appeal rise and fall over time – more so than that of most other parties – and, second, why is the appeal so much greater among some people than others?

Biology has little to say about the first. Although environmental changes, such as conflict, can and do alter individual biological predispositions, sudden environmentally mediated shifts of biological predisposition that are strong enough to alter the electoral fortunes of populist parties in multiple societies seem unlikely.

"Variations in biologically measured negativity bias appear to predict attitudes on immigration"

Interestingly, non-biological, purely environmental explanations do not provide much better answers. The popular belief is that populism surges when economies falter or tragedies unfold. While intuitively appealing, studies find little evidence for a link to any metric of a nation's fortunes.

As for why populism's appeal varies so much from person to person, many see populism as a symptom of working class angst in a world where external forces disproportionately threaten that group. That view is questionable given that support is often from those not low in socioeconomic status – think UKIP and the Tea Party. It is on this question of individual variation that biopolitical literature provides a more plausible – though far from total – explanation.

Humans have a well-established and potent negativity bias; we subconsciously respond more and pay more attention to negative than to positive events. This makes sense. Negative situations can have more severe consequences in survival terms, so successful organisms should be more sensitive to such stimuli. It is also well established that individuals vary in their degree of response to negative stimuli.

Physiologically speaking, some react nearly as strongly to positive as to negative stimuli; others

much more strongly to negative.

Work in our lab and several others suggests that, after accounting for socioeconomic status, people who are more biologically responsive to and who devote more cognitive resources to negative stimuli favour policies that could be viewed as protective.

Those with a strong negativity bias are more likely to be suspicious of new approaches and different people. They tend to prefer certainty, tradition and security. Perhaps because they are more in tune with potential dangers, they are attracted to policies they believe will limit their vulnerability – whether the perceived threat comes from outside groups, pathogens or something that violates their group norms. In the face of perceived threats, they seek in-group safety. Variations in biologically measured negativity bias appear to predict attitudes on immigration and other perceived threats – issues typically at the core of populist movements.

Explanations for the lure of populist parties are undoubtedly more complex than biological sensitivities to negativity bias. Yet the biology suggests it would be a mistake to dismiss populism's appeal as something easily countered and to conclude that populist leaders create rather than capitalise on organic populist impulses.

Biological predispositions that bolster populism are by no means immutable. At the same time, they seem significantly harder to alter than many would like to believe; a strong negativity bias is usually deeply ingrained. Support for populist parties will continue to ebb and flow – but individual biological mechanisms animating populist urges are here to stay. ■

John Hibbing and Kevin Smith are professors of political science at the University of Nebraska-Lincoln and co-authors of *Predisposed: Liberals, conservatives, and the biology of political differences* (Routledge, 2013)

ONE MINUTE INTERVIEW

You have no sex drive

Misguided notions about our sexual appetites are missing the bigger picture and making people unhappy, says **Emily Nagoski**

JON CRISPIN PHOTOGRAPHY

PROFILE

Emily Nagoski has a PhD in health behaviour and is the director of Wellness Education at Smith College in Northampton, Massachusetts. Her new book on the science of sex is *Come As You Are* (Simon & Schuster)

Why is there no such thing as a sex drive?
A drive is a motivational system to deal with life-or-death issues, like hunger or being too cold. You're not going to die if you don't have sex.

But biologists might say that if you don't reproduce, that is a form of death
Yes. That's the argument that was used when desire was being added to the way sexual dysfunctions were diagnosed in the 1970s, to justify the framing of sexual desire as a drive. But when it comes to sex, there just isn't any physical evidence of a drive mechanism.

So what's going on?
If sex is a drive then desire should be spontaneous, like a hunger. When you see a sexy person or have a stray sexy thought, it activates an internal craving or urge for sex. That's called "spontaneous desire". It feels like it comes out of the blue. But there is another way of experiencing desire which is also healthy and normal, called "responsive desire", where your interest only emerges in response to arousal. So, your partner comes over and starts kissing your neck and you're like, "oh, right, sex, that's a good idea".

Do you think an absence of spontaneous desire is normal?
Yes. If our metaphor for desire is hunger, if you are never hungry for food there will be dire consequences and that's clearly a disorder, right? That's a medical problem that needs to be fixed. But not experiencing spontaneous hunger for sex doesn't have dire consequences; it is not a medical disorder. I think the reason we expect everyone to have spontaneous desire is because that's how most men experience it.

What proportion of people experience desire in this way?
Roughly 70 per cent of men typically experience spontaneous desire and something like 10 to 20 per cent of women have spontaneous desire as their primary desire style. But for all of us it depends on the context.

What do you think about drugs being developed to treat the "lack" of spontaneous desire in women?
A drug called Flibanserin has recently been resubmitted to the US Food and Drug Administration, targeted specifically at spontaneous desire. I think its makers genuinely believe spontaneous desire is the only normal way to experience desire. I want us to start thinking of responsive desire as normal and healthy.

But many people who don't experience spontaneous desire might like to...
Spontaneous desire is totally fun. But you're not broken just because you're not experiencing it. Spontaneous desire isn't necessary for sexual pleasure. Is it more important that people crave sex than it is that they enjoy the sex they're having? One of the best ways to make your sex life suck is to genuinely believe that the way you're experiencing sexual desire is dysfunctional.

Interview by Alison George

Tapping the incredible weirdness of water

We need to harness water's strange behaviour to make sure there's enough to go around says physicist **Marcia Barbosa**

I AM fascinated by water. We can all agree that a liquid that occupies 70 per cent of Earth's surface and two-thirds of our body is very important. However, when I tell friends and family that I have dedicated 15 years of my life to studying water, they look at me with pity. Don't we already know everything about water? Then they suggest that, as a physicist, I should be studying something less common, such as carbon nanotubes.

It is a mistake to underestimate water. The more you look into it, the less common it seems.

Water is weird. It has 72 anomalies – physical and chemical properties that are very different from other materials. For scientists, anomalies can be the basis of technological breakthroughs. This was the case with silicon – its unusual properties have given us semiconductors, and hence the digital technology that has transformed our lives.

But while silicon exhibits about a dozen anomalies, water has six times more. This is what allowed water to become central to the development of life.

What makes water so strange? Its most well known anomaly is the way its density changes with temperature. Most materials contract on cooling, so they occupy less volume when solid than when they are liquid. This is not the case with ice, which floats in water and takes up more space than liquid water. The most amazing thing, however, is that water at 0 °C floats on water at 4 °C. This means that at sub-zero temperatures, lakes and rivers freeze from the top to the bottom, leaving a lowest layer of warmer 4 °C water where fish and plants survive.

"This is like being able to move more freely as you get squashed in a crowd"

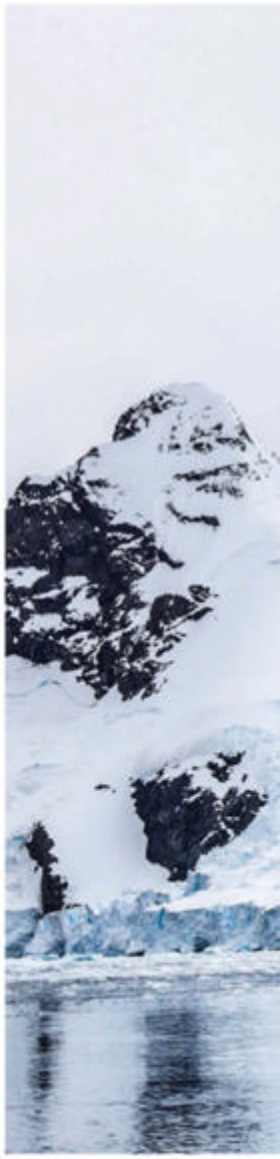
Another atypical property of water is its high heat capacity, which means that a large amount of heat input is needed to raise its temperature. This anomaly makes water an excellent heat reservoir in our bodies and in our planet. It is also a good buffer against temperature swings, providing a stability that helped life to develop. The best technological tool that the anomalies of water have given us is life itself.

These properties are possible because water molecules form hydrogen bonds with each other. The peculiarity of these hydrogen bonds is that each molecule can form up to four of them, making a tetrahedral structure that is quite stable. This bonded network also contributes to the strange way water moves.

In most liquids, particles become less able to move as the material becomes denser. For water this is not the case. At high density – or under high pressure – the molecules move around faster, not slower as we would imagine. This is a bit like being able to move around more freely as you get squashed in a tightly packed crowd. This counter-intuitive behaviour means that when water is confined within carbon nanotubes, the molecules form a single line in the centre. This allows them to flow a thousand times faster than expected – a surprising discovery made in 2001. This "superflow" of water in nanotubes is the focus of my research.

This mechanism has long been exploited by nature. Biological channels such as the aquaporins in cell membranes have narrow pores that allow the rapid flow of water, just like in carbon nanotubes. They also have charged residue at the centre of the pore that repels salts. In this way, kidneys make use of these biological nanotubes to desalinate our bodily fluids, and do so in a very energy-efficient way. What if we could harness this desalination process outside the body?

PROFILE
Marcia Barbosa is a physicist at The Federal University of Rio Grande do Sul, Brazil. Her research focuses on complex fluids



Ice takes up more room than liquid water – just one of its many quirks

Today, 1 in 6 people on Earth have limited access to clean water. But this is an even bigger problem than it first seems, because we don't just need water for drinking – we need it for eating too. Around 70 per cent of water consumption is used for agriculture, compared to 10 per cent for household use. By 2025, the world's population is expected to rise by another billion and, if nothing is done to address the issue, it is estimated that two-thirds of the population will be living in areas with a severe lack of fresh water.

To avoid this drastic scenario, measures are being taken to improve the water distribution infrastructure. However, this depends on existing amounts of fresh water. The only way to increase water supply on a large scale is

ALEX CORNELL

desalination. The most common desalination procedures are distillation and reverse osmosis, which entails forcing salty water through a membrane that is impermeable to salt. These methods currently provide fresh water for 300 million people. But even running at optimal efficiency, they are still too expensive for many developing countries.

This is where work on water's weird properties comes in. Research is under way on at least three desalination technologies that rely on recent discoveries about water's anomolous superflow when confined to the nanoscale. One approach, already in production, is to use a membrane with aquaporins in combination with reverse osmosis, which can produce fresh water using less energy than reverse osmosis alone.

Another approach is to create an array of densely packed nanotubes that only allow the passage of water molecules, not salt. This speeds up the water flow and, in combination with reverse osmosis, is already being commercialised but still requires tests for long term stability and scale. The third method combines distillation, reverse osmosis and carbon nanotube superflow – a speedier method because it uses water vapour, which flows even faster.

Although these techniques have yet to be rolled out, it is hoped they will cut the high energetic cost of separating water from salt, especially with the advent of large scale, low cost production of carbon nanotubes and aquaporins.

But what happens in landlocked regions with no sea water? Here, some promising research on harvesting water from fog is in the early stages. The idea is to mimic the way insects such as the Stenocara beetle capture small water droplets from the atmosphere. This beetle has a water-attracting region on its back that transforms vapour into liquid water, then it uses gravity and a water-repelling region to bring the liquid to its mouth. Coupling a similar process with nanotube superflow can improve the efficiency of water collection.

Nature is already adept at exploiting water's strange behaviour. I have high hopes we too can exploit these properties to help solve the world's water shortage problems. ■

Deep inside you is a personal guidebook that influences almost everything you do. How did it get there and why is it so powerful, wonders **Graham Lawton**

THE day I sat down to write this article the news was rather like any other day. A teenager had been found guilty of plotting to behead a British soldier. Fighting had broken out again in Ukraine. Greece was accusing its creditors of being motivated by ideology rather than economic reality. Some English football fans were filmed racially abusing a man on the Paris subway. Admittedly, all of that day's stories were unique in themselves. But at the root they were all about the same thing: the powerful and very human attribute we call belief.

Beliefs define how we see the world and act within it; without them, there would be no plots to behead soldiers, no war, no economic crises and no racism. There would also be no cathedrals, no nature reserves, no science and no art. Whatever beliefs you hold, it's hard to imagine life without them. Beliefs, more than anything else, are what make us human. They also come so naturally that we rarely stop to think how bizarre belief is.

In 1921, philosopher Bertrand Russell put it succinctly when he described belief as "the central problem in the analysis of mind". Believing, he said, is "the most 'mental' thing we do" – by which he meant the most removed from the "mere matter" that our brains are made of. How can a physical object like a human brain believe things? Philosophy has made little progress on Russell's central problem. But increasingly, scientists are stepping in.

"We once thought that human beliefs were too complex to be amenable to science," says Frank Kreuger, a neuroscientist at George Mason University in Fairfax, Virginia. "But that era has passed." What is emerging is a picture of belief that is quite different from common-sense assumptions of it – one that has the potential to change some widely held beliefs about ourselves. Beliefs are fundamental to our lives, but when it comes to what we believe and why, it turns out we have a lot less control than you might think.

PEROU/GALERIES/CORBIS FELIX HUG/CORBIS

Our beliefs come in many shapes and sizes, from the trivial and the easily verified – I believe it will rain today – to profound leaps of faith – I believe in God. Taken together they form a personal guidebook to reality, telling us not just what is factually correct but also what is right and good, and hence how to behave towards one another and the natural world. This makes them arguably not just the most mental thing our brains do but also the most important. "The prime directive of the brain is to extract meaning. Everything else is a slave system," says psychologist Peter Halligan at Cardiff University, UK.

Yet, despite their importance, one of the long-standing problems with studying beliefs is identifying exactly what it is you are trying to understand. "Everyone knows what belief is until you ask them to define it," says Halligan. What is generally agreed is that belief is a bit like knowledge, but more personal. Knowing something is true is different from believing it to be true; knowledge is objective, but belief is subjective. It is this leap-of-faith aspect that gives belief its singular, and troublesome, character.

Philosophers have long argued about the relationship between knowing and believing. In the 17th century, René Descartes and Baruch Spinoza clashed over this issue while trying to explain how we arrive at our beliefs. Descartes thought understanding must come first; only once you have understood something can you weigh it up and decide whether to believe it or not. Spinoza didn't agree. He claimed that to know something is to automatically believe it; only once you have believed something can you un-believe it. The difference may seem trivial but it has major implications for how belief works.

If you were designing a belief-acquisition system from scratch it would probably look like the Cartesian one. Spinoza's view, on the other hand, seems implausible. If the default state of the human brain is to unthinkingly accept what we learn as true, then our common-sense understanding of beliefs as something we reason our way to goes out of the window. Yet, strangely, the evidence seems to support Spinoza. For example, young children are extremely credulous, suggesting that the ability to doubt and reject requires more mental resources than acceptance. Similarly, fatigued or distracted people are more susceptible to persuasion. And when neuroscientists joined the party, their findings added weight to Spinoza's view.

Your credulous brain

The neuroscientific investigation of belief began in 2008, when Sam Harris at the University of California, Los Angeles, put people into a brain scanner and asked them whether they believed in various written statements. Some were simple factual propositions, such as "California is larger than Rhode Island"; others were matters of personal belief, such as "There is probably no God". Harris found that statements people believed to be true produced little characteristic brain activity – just a few brief ›

TOP 10 DELUSION-LIKE BELIEFS AMONG UK POPULATION

Your body, or part of your body, is misshapen or ugly **46.4%**

You are not in control of some of your actions **44.3%**

You are an exceptionally gifted person that others do not recognise **40.5%**

Certain places are duplicated, i.e. are in two different locations at the same time **38.7%**

People say or do things that contain special messages for you **38.5%**

flickers in regions associated with reasoning and emotional reward. In contrast, disbelief produced longer and stronger activation in regions associated with deliberation and decision-making, as if the brain had to work harder to reach a state of disbelief. Statements the volunteers did not believe also activated regions associated with emotion, but in this case pain and disgust.

Harris's results were widely interpreted as further confirmation that the default state of the human brain is to accept. Belief comes easily; doubt takes effort. While this doesn't seem like a smart strategy for navigating the world, it makes sense in the light of evolution. If the sophisticated cognitive systems that underpin belief evolved from more primitive perceptual ones, they would retain many of the basic features of these simpler systems. One of these is the uncritical acceptance of incoming information. This is a good rule when it comes to sensory perception as our senses usually provide reliable information. But it has saddled us with a non-optimal system for assessing more abstract stimuli such as ideas.

"The world would be a better place if we believed in our beliefs less strongly"

Further evidence that this is the case has come from studying how and why belief goes wrong. "When you consider brain damage or psychiatric disorders that produce delusions, you can begin to understand where belief starts," says Halligan. Such delusions include beliefs that seem bizarre to outsiders but completely natural to the person concerned. For example, people sometimes believe that they are dead, that loved ones have been replaced by imposters, or that their thoughts and actions are being controlled by aliens. And, tellingly, such delusions are often accompanied by disorders of perception, emotional processing or "internal monitoring" – knowing, for example, whether you initiated a specific thought or action.

These deficits are where the delusions start, suggests Robyn Langdon of Macquarie University in Sydney, Australia. People with delusions of alien control, for example, often have faulty motor monitoring, so fail to register actions they have initiated as their own. Likewise, people with the delusion known as "mirror-self misidentification" fail to recognise their own reflection. They often also have a sensory deficit called mirror agnosia: they don't "get" reflective surfaces. A mirror looks like a window and if asked to retrieve an object reflected in one they will try to reach into the mirror or around it. Their senses are telling them that the person in the mirror isn't them, and so they believe this to be true. Again, we trust the evidence of our senses, and if they tell us that black is white, we generally do well to believe them.

You may think that you would never be taken in like that but, says Langdon, "we all default to such believing, at least initially". Consider the experience of watching a magic show. Even though you know it's all an illusion, your instinctive reaction is that the magician has altered the laws of physics.

Misperceptions are not delusions, of course. Witnessing someone being sawn in half and put back together doesn't mean we then believe that people can be safely sawn in half. What's more, sensory deficits do not always lead to delusional beliefs. So what else is required? Harris's brain imaging studies delivered an important clue: belief involves both reasoning and emotion.

The feeling of rightness

The formation of delusional belief probably also requires the emotional weighing-up process to be disrupted in some way. It may be that brain injury destroys it altogether, causing people to simply accept the evidence of their senses. Or perhaps it just weakens it, lowering the evidence threshold required to accept a delusional belief.

For example, somebody with a brain injury that disrupts their emotional processing of faces may think "the person who came to see me yesterday looked like my wife, but didn't feel like her, maybe it was an impostor. I will reserve judgement until she comes back." The next meeting feels similarly disconnected, and so the hypothesis is confirmed and the delusion starts to grow.

According to Langdon and others, this is similar to what goes on in the normal process of belief formation. Both involve incoming information together with unconscious reflection on that information until a "feeling of rightness" arrives, and a belief is formed.

Certain people are out to harm or discredit you
33.8%

Your thoughts are not fully under your control
33.6%

There is another person who looks and acts like you
32.7%

Some people are duplicated, i.e. are in two places at the same time
26.2%

People you know disguise themselves as others to manipulate or influence you
24.9%

GORDON SCAMMELL/LOOP IMAGES/CORBIS

Our judgement of which ideas feel right to believe in is extremely fallible

This two-stage process could help explain why people without brain damage are also surprisingly susceptible to strange beliefs. Our natural credulity is one thing, and is particularly likely to lead us astray when we are faced with claims based on ideas that are difficult to verify with our senses – "9/11 was an inside job", for example. The second problem is with the "feeling of rightness", which would appear to be extremely fallible (see "What's your delusion?", page 32).

So where does the feeling of rightness come from? The evidence suggests that it has three main sources – our evolved psychology, personal biological differences and the society we keep.

The importance of evolved psychology is illuminated by perhaps the most important belief system of all: religion. Although the specifics vary widely, religious belief per se is remarkably similar across the board. Most religions feature a familiar cast of characters: supernatural agents, life after death, moral directives and answers to existential questions. Why do so many people believe such things so effortlessly?

According to the cognitive by-product theory of religion, their intuitive rightness springs from basic features of human cognition that evolved for other reasons. In particular, we tend to assume that agents cause events. A rustle in the undergrowth could be a predator or it could just be the wind, but it pays to err on the side of caution; our ancestors who assumed agency would have survived longer and had more offspring. Likewise, our psychology has evolved to seek out patterns because this was a useful survival strategy. During the dry season, for example, animals are likely to congregate by a water hole, so that's where you should go hunting. Again, it pays for this system to be overactive.

This potent combination of hypersensitive "agenticity" and "patternicity" has produced a human brain that is primed to see agency and purpose everywhere. And agency and purpose are two of religion's most important features – particularly the idea of an omnipotent but invisible agent that makes things happen and gives meaning to otherwise random events. In this way, humans are naturally receptive to religious claims, and when we first encounter them – typically as children – we unquestioningly accept them. There is a "feeling of rightness" about them that originates deep in our cognitive architecture.

According to Kreuger, all beliefs are acquired in a similar way. "Beliefs are on a spectrum but they all have the same quality. A belief is a belief."

Our agent-seeking and pattern-seeking brain usually serves us well, but it also makes us susceptible to a wide range of weird and irrational beliefs, from the paranormal and supernatural to conspiracy theories, superstitions, extremism and magical ›

WHAT'S YOUR DELUSION?

Normal people believe in the strangest things. About half of US adults endorse at least one conspiracy theory. Belief in paranormal or supernatural phenomena is widespread, and superstition and magical thinking are nearly universal.

Surprisingly large numbers of people also hold beliefs that a psychiatrist would class as delusional. In 2011, psychologist Peter Halligan at Cardiff University assessed how common such beliefs were in the UK (see "Top 10 delusion-like beliefs among UK population", page 30).

He found that more than 90 per cent of people held at least one, to some extent. They included the belief that a celebrity is secretly in love with you, that you are not in control of some of your actions, and that people say or do things that contain special messages for you (*Psychopathology*, vol 44, p 106). None of Halligan's subjects were troubled by their strange beliefs. Nonetheless, the fact that they are so common suggests that the "feeling of rightness" that accompanies belief is not always a reliable guide to reality.

ABBAS / MAGNUM PHOTOS

Instead of reasoning our way to beliefs, the facts we choose to believe depend on our moral position

thinking. And our evolved psychology underpins other beliefs too, including dualism – viewing the mind and body as separate entities – and a natural tendency to believe that the group we belong to is superior to others.

A second source of rightness is more personal. When it comes to something like political belief, the assumption has been that we reason our way to a particular stance. But, over the past decade or so, it has become clear that political belief is rooted in our basic biology. Conservatives, for example, generally react more fearfully than liberals to threatening images, scoring higher on measures of arousal such as skin conductance and eye-blink rate. This suggests they perceive the world as a more dangerous place and perhaps goes some way to explaining their stance on issues like law and order and national security.

Another biological reflex that has been implicated in political belief is disgust. As a general rule, conservatives are more easily disgusted by stimuli like fart smells and rubbish. And disgust tends to make people of all political persuasions more averse to morally suspect behaviour, though the response is stronger in conservatives. This has been proposed as an explanation for differences of opinion over important issues such as gay marriage and illegal immigration. Conservatives often feel strong revulsion at these violations of the status quo and so judge them to be morally unacceptable. Liberals are less easily disgusted and less likely to judge them so harshly.

Different realities

These instinctive responses are so influential that people with different political beliefs literally come to inhabit different realities. Many studies have found that people's beliefs about controversial issues align with their moral position on it. Supporters of capital punishment, for example, often claim that it deters crime and rarely leads to the execution of innocent people; opponents say the opposite.

That might simply be because we reason our way to our moral positions, weighing up the facts at our disposal before reaching a conclusion. But there is a large and growing body of evidence to suggest that belief works the other way. First we stake out our moral

YOUR FIVE CORE BELIEFS

One of the most interesting things about belief is that it varies enormously from person to person, especially on issues that really matter such as politics and religion. According to research by Gerard Saucier of the University of Oregon, these myriad differences can be boiled down to five basic "dimensions" (*Journal of Personality and Social Psychology*, vol 104, p 921). At their core, he says, these concern what we consider to be worthy sources of value and goodness in life, whether it be a concept, an object, a supernatural being or a historical person. Your belief system is the aggregate of your position on each of these five dimensions, which are independent of each other.

01
Traditional religiousness:
level of belief in mainstream theological systems such as Christianity and Islam

02
Subjective spirituality:
level of belief in non-material phenomena such as spirits, astrology and the paranormal

03
Unmitigated self-interest:
belief in the idea that hedonism is a source of value and goodness in life

04
Communal rationalism:
belief in the importance of common institutions and the exercise of reason

05
Inequality aversion:
level of tolerance of inequality in society, a proxy of the traditional left-right political split

positions, and then mould the facts to fit.

So if our moral positions guide our factual beliefs, where do morals come from? The short answer: not your brain.

According to Jonathan Haidt at the University of Virginia, our moral judgements are usually rapid and intuitive; people jump to conclusions and only later come up with reasons to justify their decision. To see this in action, try confronting someone with a situation that is offensive but harmless, such as using their national flag to clean a toilet. Most will insist this is wrong but fail to come up with a rationale, and fall back on statements like "I can't explain it, I just know it's wrong".

This becomes clear when you ask people questions that include both a moral and factual element, such as: "Is forceful interrogation of terrorist suspects morally wrong, even when it produces useful information?" or "Is distributing condoms as part of a sex-education programme morally wrong, even when it reduces rates of teenage pregnancy and STDs? People who answer "yes" to such questions are also likely to dispute the facts, or produce their own alternative facts to support their belief. Opponents of condom distribution, for example, often state that condoms don't work so distributing them won't do any good anyway.

What feels right to believe is also powerfully shaped by the culture we grow up in. Many of our fundamental beliefs are formed during childhood. According to Kreuger, the process begins as soon as we are born, based initially on sensory perception – that objects fall downwards, for example – and later expands to more abstract ideas and propositions. Not surprisingly, the outcome depends on the beliefs you encounter. "We are social beings. Beliefs are learned from the people you are closest to," says Kreuger. It couldn't be any other way. If we all had to construct a belief system from scratch based on direct experience, we wouldn't get very far.

This isn't simply about proximity; it is also about belonging. Our social nature means that we adopt beliefs as badges of cultural identity. This is often seen with hot-potato issues, where belonging to the right tribe can be more important than being on the right side of the evidence. Acceptance of climate change, for example, has become a shibboleth in the US – conservatives on one side, liberals on the other. Evolution, vaccination and others are similarly divisive issues.

So, what we come to believe is shaped to a large extent by our culture, biology and psychology. By the time we reach adulthood, we tend to have a relatively coherent and resilient set of beliefs that stay with us for the rest of our lives (see "Your five core beliefs", left). These form an interconnected belief system with a relatively high level of internal consistency. But the idea that this is the product of rational, conscious choices is highly debatable. "If I'm totally honest I didn't really choose my beliefs: I discover I have them," says Halligan. "I sometimes reflect upon them, but I struggle to look back and say, what was the genesis of this belief?"

Forget the facts

The upshot of all this is that our personal guidebook of beliefs is both built on sand and also highly resistant to change. "If you hear a new thing, you try to fit it in with your current beliefs," says Halligan. That often means going to great lengths to reject something that contradicts your position, or seeking out further information to confirm what you already believe.

That's not to say that people's beliefs cannot change. Presented with enough contradictory information, we can and do change our minds. Many atheists, for example, reason their way to irreligion. Often, though, rationality doesn't even triumph here. Instead, we are more likely to change our beliefs in response to a compelling moral argument – and when we do, we reshape the facts to fit with our new belief. More often than not, though, we simply cling to our beliefs.

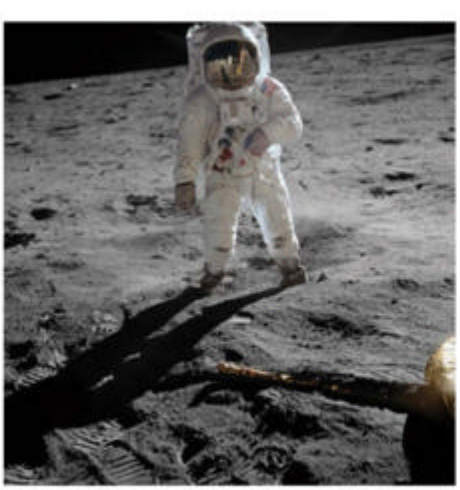
All told, the uncomfortable conclusion is that some if not all of our fundamental beliefs about the world are based not on facts and reason – or even misinformation – but on gut feelings that arise from our evolved psychology, basic biology and culture. The results of this are plain to see: political deadlock, religious strife, evidence-free policy-making and a bottomless pit of mumbo jumbo. Even worse, the deep roots of our troubles are largely invisible to us. "If you hold a belief, by definition you hold it to be true," says Halligan. "Can you step outside your beliefs? I'm not sure you'd be capable."

The world would be a boring place if we all believed the same things. But it would surely be a better one if we all stopped believing in our beliefs quite so strongly. ■

Graham Lawton is the deputy editor of *New Scientist*

Photo finish

The race is on to reinvent the photo. Will cameras last the distance, asks Jon Cartwright



NASA

LIKE a lot of professionals, Laura Pannack isn't crazy about modern cameras. Granted, the London-based photographer keeps an iPhone in her pocket for the occasional snapshot, but really she likes nothing more than to take out her well-worn Hasselblad and hear the satisfying pah-clunk of a mechanical shutter. "As an artist and a photographer, I do believe in embracing new mediums," she says. "But, to be honest, I use old technology more than new."

With cameras, though, what counts as old is relative. Pannack's camera phone and Hasselblad may be separated by several decades of innovation, but they have more in common than most gadgets spanning this timescale. Both focus light into an image using a series of glass lenses, like every other camera on the market. Whether that image is then captured on film or on the latest smartphone's digital sensor, it is the result of a technique invented in the 1830s.

Photography has been the medium of the modern age, recording everything from momentous events like Neil Armstrong on the moon and the Tank Man in Tiananmen Square, to Marilyn Monroe on a subway grating and that selfie you took on New Year's Eve, dressed as an orangutan and with a banana squashed in your friend's ear. But all that could be just the start, because the way we take photographs and what we do with them afterwards is changing dramatically. The job performed by finely ground slivers of glass is being eclipsed by the work of finely crafted algorithms. As they take the lead, the 180-year reign of the lens might be over (see timeline, page 37). It is a fundamental reimagining of photography and, like an ageing Polaroid, the camera as we know it is fading from existence.

Digital photography has entered an age of extremes. There are gigapixel cameras that capture ultra-high-res images, and so-called single-pixel cameras that construct an image by taking multiple snaps with just one relatively cheap, low-powered detector . But the real battle for the future of photography is happening in our pockets. Although smartphone manufacturers have pushed camera technology massively in recent years, they are finding it increasingly difficult to cram a stack of lenses into a wafer-thin body. When Apple released promo shots of the iPhone 6 last year, it airbrushed out the protruding lens – the only component that could not be sufficiently miniaturised. But while the lens has reached its limit, computational photography is just getting going.

Most smartphone cameras give us the ability to take a panorama, essentially a super-wide-angle image. As you pivot on the spot, an algorithm records several images and then ›

MICHAEL GLENWOOD

stitches them together, making slight adjustments for exposure, parallax and so on, so that the seams are invisible. Another common phone feature is high dynamic range (HDR) imaging, which allows you to photograph a very high-contrast scene – a person standing with the sun directly behind them, for instance – and still see details of their face rather than just a silhouette.

The HDR function works by merging several images of the same scene: at least one image with a long exposure to capture detail in the shadows, and one image with a short exposure to preserve highlight detail. "Under the hood, a lot of these computational-imaging techniques are already taking place," says computer scientist Wolfgang Heidrich at the King Abdullah University of Science and Technology in Thuwal, Saudi Arabia.

Computional trickery will soon be covering up even bigger imperfections. One shortcoming of smartphone photos, for example, is blurry edges – the natural product of cheap, miniaturised optics. Traditional cameras do not suffer from this because they usually use larger lenses that contain many individual elements. That is obviously a no-no for smartphones, so Heidrich is developing an algorithm that can correct optical aberrations. Since a bad lens typically affects the primary colours differently, the algorithm looks for areas where the red, green and blue layers that make up the image are misaligned. It then adjusts the image until they line up, leaving it pin sharp.

Blurring can also come from camera shake, which is all too common when holding a phone at arm's length. But an algorithm developed by Kari Pulli of photography tech start-up Light in Palo Alto, California, can help keep things steady. It takes readings on the fly from a smartphone's built-in gyroscope, and uses them to adjust for motion blur without sacrificing genuine movement in the scene.

Risk and reward

Heidrich's and Pulli's ideas are set to improve smartphone image quality, but they will not do much to make up for our amateurish blunders. After all, photography – in the spirit of the pioneering French photojournalist Henri Cartier-Bresson – is all about the "decisive moment", that crucial split second when you press the shutter. Pannack agrees. More goes into great photos than just a good-quality image, she says. Creativity is wrapped up with risk and what Pannack calls "beautiful mistakes". Get it right and you've captured your friend's expression the moment the banana finds his ear; get it wrong and you have accidentally focused on the background.

This is where we could see the biggest shift in how we take photos. What if we could simply take a shot and only later decide what its composition and focus should be? Hard though it might be to imagine this, computational photography is already showing us how it could be done.

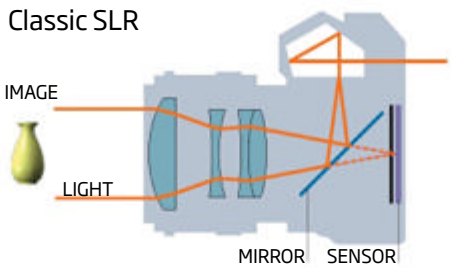

LYTRO

Refocusing a picture long after you took it is within our grasp

Tricks of the light

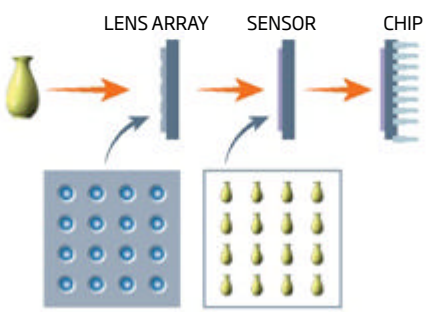
Our traditional concept of a camera could soon be old hat, with the advent of devices boasting multiple lenses or none at all

Classic SLR



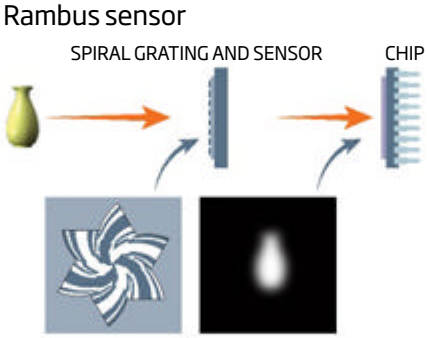
A camera lens focuses light on to film or a sensor

PiCam



Sixteen lenses capture images of the subject from slightly different angles, providing depth information which can later be used to refocus the captured image and adjust the viewpoint

Rambus sensor



Doing away with a lens altogether, a tiny spiral aperture creates blob-like diffusion patterns on a sensor. From these, algorithms can build the image

In 2011, the California-based company Lytro launched the first consumer "light-field" camera. It still focuses light through a main lens towards a sensor, as in a normal camera. But the Lytro has an extra array of micro-lenses which capture bundles of rays and focus them on to individual pixels. The result is a device that captures the direction, as well as the intensity, of incoming light – known as the light field.

Using this information, algorithms can work out how the light would have behaved if the main lens had focused it differently. That leads to the key benefit of a light-field camera: the ability to refocus photos after they are taken. If your friend is out of focus, you can tap where they are on the screen and, as if you've had an instant cataract removal, their face turns crystal clear. Even better, the algorithms can calculate how the scene would look if the light had entered the lens at a slightly different angle, giving the option of viewing the scene from more than one perspective. If you were photographing a football tackle, you might be able to adjust the image to show the point of contact between the players, for example.

Similar tech is headed to smartphones. The PiCam replaces the single lens on a smartphone with an array of 16 smaller ones (see diagram, left). These are a small distance apart, so can also record depth information. "It kind of mimics the human eyes," says Kartik Venkataraman, CEO and co-founder of Pelican Imaging, also in California, which developed the technology. Next-gen selfies will come in 3D, ready to be printed.

This year PiCam is being released as a development kit to smartphone manufacturers and we can expect light-field photography to be widely available soon. But not everyone involved in computational photography believes Lytro or PiCam have got the right idea. Pulli points out that taking up sensor space with a lens array kills the resolution of the final shot, unless yet more algorithms are employed to merge several low-res images. "You pay with low resolution, and have to expend a

lot of effort trying to get it back," he says.

Even so, there are other ideas for how to exploit light fields to great effect. One of these, says Kyros Kutulakos, a computer scientist at the University of Toronto in Canada, is relighting – the ability to impose light that was not there to begin with on a scene. Whereas traditional photographers have to laboriously set up a separate flash unit away from their camera to achieve certain lighting conditions, light-field cameras could add a spotlight effect automatically. Their depth information equates to a 3D map of the scene, which makes it possible to work out exactly where the shadows would naturally fall.

Kutulakos is developing yet another trick: separating light that has bounced directly off the subject from light that has bounced indirectly, scattered by different surface angles and textures. This technique involves

"What if we could simply take a shot and decide how to compose it afterwards?"

placing an electronic, slit-shaped mask over a camera's internal flash unit, limiting the outward light to one plane; another mask shields the camera's sensor. When the masks match up in the same plane, only the direct light reaches the sensor.

Cameras – and our eyes – normally perceive a mixture of direct and indirect light. But things look quite different if direct light is allowed to dominate. A glass turns black. Yellow foam turns grey. A latex glove becomes almost invisible. "We are only just starting to realise what happens when you take pictures in this way," says Kutulanos.

Something particularly interesting happens when you photograph faces in direct light: they look stark and haggard, a consequence of masking out all the light scattered indirectly from beneath the skin. Indirect light, on the other hand, reveals perfectly smooth features and bright white teeth. You wouldn't want this photo as your profile pic – it has an overall red cast – but Kutulanos believes a boost of the indirect channel could give anyone an instant makeover. More generally, if you can distinguish between the direct and indirect natural light in a scene, you will be better equipped to manipulate images, for example using Photoshop-style edits.

For Kutulanos, this is just another illustration of the level of control that could see computational photography supplanting traditional techniques. "I have colleagues who have been announcing the death of the camera for a few years already," he says.

And that death is on the cards. If the lens is the essence of traditional photography, then the final nail in the coffin will be imaging ›

CAMERA ACTION

1826-1827
Oldest surviving photo, *View from the Window at Le Gras*, by inventor of photography Nicéphore Niépce


NICEPHORE NIEPCE

1861
James Clerk Maxwell produces the first colour photo, made by overlaying red, green and blue images of a tartan ribbon


JAMES CLERK MAXWELL

1878
With exposure times down from minutes to hundredths of a second, Eadweard Muybridge captures a horse in full gallop


E.MUYBRIDGE/GETTY

1947
Edwin Land demonstrates the Polaroid "instant camera", which lets people have photos to view soon after they are taken


POLAROID/PA ARCHIVES/ PRESS ASSOCIATION

1957
Russel Kirsch at the US National Bureau of Standards scans a photo of his newborn son into a computer, creating the first digital image


RUSSELL A. KIRSCH/ US NATIONAL BUREAU OF STANDARDS

1975
Kodak engineer Steve Sasson creates the first digital camera, which took 23 seconds to record a 0.01 megapixel image to cassette tape


KODAK

1992
An image of CERN doo-wop group, Les Horribles Cernettes, becomes first photo uploaded to the web by Tim Berners-Lee

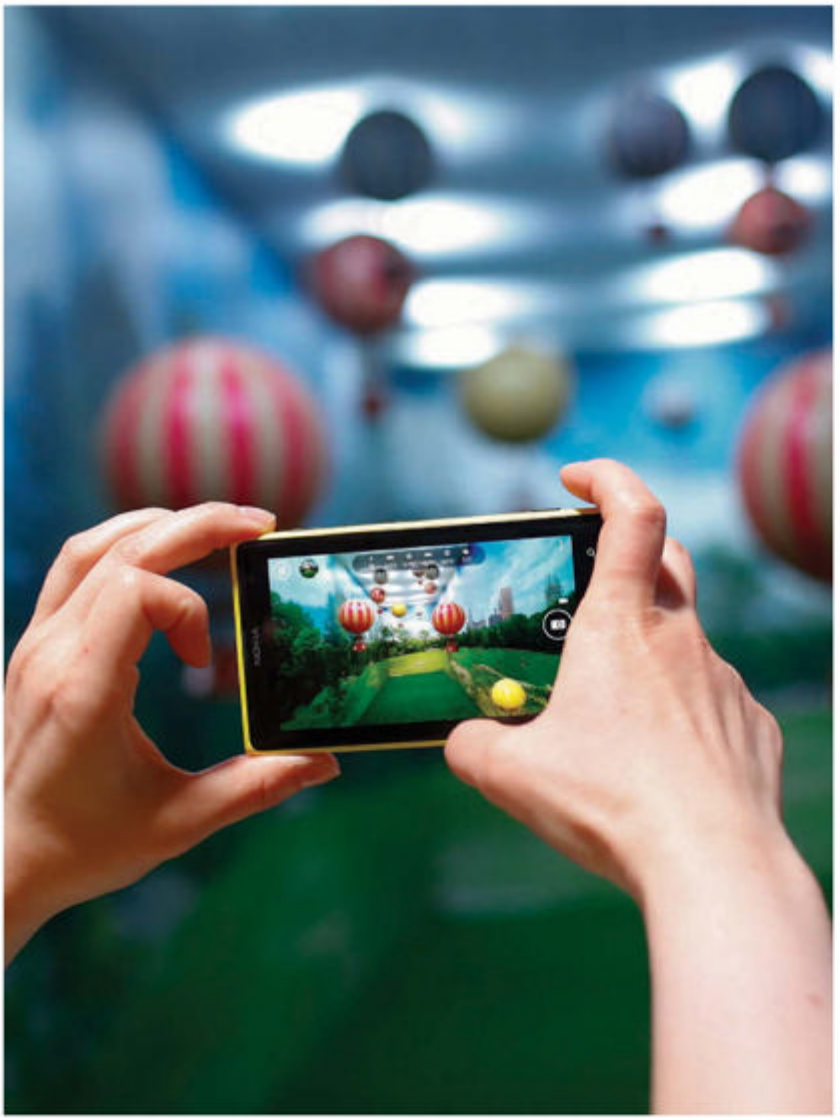
SILVANO DE GENNARO/CERN

1997
Philippe Kahn introduces photo messaging to the world by linking a camera and mobile phone to share a photo of his daughter


PHILLIPE KAHN

2014
Patrick Gill at US technology company Rambus develops a device that captures images without using a lens (see main story)


PATRICK GILL



SHANNON STAPLETON/REUTERS

Making memories

You either can't stand them or are one yourself: people who choose to witness everything through their smartphone cameras. Those outstretched arms and selfie sticks have become a common sight. But is the habit affecting our ability to remember?

In 2013, psychologist Linda Henkel at Fairfield University in Connecticut decided to find out, by monitoring people as they explored an art museum. One group took no photos, another took photos of everything, and a third group took photos only of specific details. She then tested what they recalled.

Those who took photos indiscriminately remembered less than those who browsed the exhibits without a camera, possibly because the frequent snappers relied on the cameras to record what they were seeing, says Henkel. But those who used their cameras to zoom in on the details of exhibits recalled just as much as those without cameras. "It focuses your attention," says Henkel. "All research tells us that focusing your attention is going to lead to better memory."

Henkel's study suggests that constant use of cameras could be free from ill effects, as long as we are selective and pay attention to what we are taking photos of. But photography can skew memory in another way.

In a classic 2002 experiment, Kimberley Wade, now at the University of Warwick, UK, and her colleagues gave a group of adults fake photos of a balloon ride and told them it took place when they were children. Half of them claimed they could recall the fictional event, or at least certain details.

For Henkel, this shows the dangers of the kind of photo-manipulation that computational photography will make all the easier (see main story).

technology that has no need of one. Such a device has been designed by neuroscientist-turned-engineer Patrick Gill at Rambus, a technology company based in California. It forgoes a lens for a single spiral-shaped aperture, which diffracts incoming light into numerous mini-spiral "pixels", each as unique as a snowflake. Although these mini-spirals arrive at the sensor in a blurry mess, their individual shapes allow an algorithm to unpack them (see diagram, page 36). It is then just a matter of recording their intensity – as a digital camera does with normal pixels – to recreate the original scene.

For now, lensless technology is primitive. Gill shows an image of the *Mona Lisa* captured on his device. Although the enigmatic smile is there, the painting appears grey and blotchy. Nonetheless, it speaks volumes for the power

> "Some people have been announcing the death of the camera for years"

of computational photography that, to preserve a moment in time, the most recognisable part of a camera is not even necessary. "I shouldn't even call them cameras," says Gill. "If my Rambus colleagues were here right now they'd give me a slap on the wrist!"

Not much bigger than a breadcrumb, and incredibly cheap to manufacture, Gill's lensless cameras – or "lensless smart sensors", as he is supposed to call them – could grace the surface of almost anything, and make photography even more ubiquitous than it already is. That raises questions about the effect incessant photography is having on our perception of the past (see "Making memories", left), as well as questions about the future of those who make a living from being in the right place at the right time. If cameras are everywhere, and capturing the decisive moment is simply a matter of trawling back through an endless photostream, what place is there for a pro?

Pannack stands by her trusty Hasselblad, despite having just returned from Romania to discover that security scanners had blanked 30 rolls of film. "It's kind of like saying, if we reinvented the paintbrush, would all painters be out of a job?" she says. "I don't think so, because they would still need an eye – they need to know what works and what doesn't."

But with new technologies making photography snappier than ever, perhaps the rest of us can work on cultivating that expert eye. ■

Jon Cartwright is a freelance journalist based in Bristol, UK

WIN a Lytro Illum! Visit bit.ly/NSLightField

upp™

FUEL CELL TECHNOLOGY

Tomorrow's technology today, available at BeUpp.com/fuelcell

Upp is a portable fuel cell power solution. Technology used in space exploration and land-based vehicles has been developed further into a unique, next-generation power pack. Upp consists of two parts, a MicroGenerator and fuel cartridge. Using hydrogen as the fuel, Upp creates electricity instantly on-the-go for your smartphone and other compatible USB devices. What was once big and expensive is now smaller and affordable and ready to use.

Find out more about Upp at BeUpp.com/fuelcell

BeUpp.com

The processes that allow life to thrive in deep-sea vents are happening all around us, says marine biologist **Nick Higgs**

Alternative lifestyle

NORBERT WU/MINDEN PICTURES

Even in shallow waters, not all organisms live off light

A FEW years ago, as my bride and I sat finishing our wedding breakfast, I sipped my champagne, oblivious to what was sitting on the white linen-clad table in front of me. I certainly never imagined they would shape my research.

Although we were getting married in the UK, my roots lie in the Bahamas. My wife had asked my parents to bring over shells to decorate the tables. Some of them caught the eye of my PhD supervisor, Crispin Little. "Nick, these are all lucinid shells," he said. I picked one up from the table in front of me. "Huh," I exclaimed, "so they are."

Lucinid clams are unusual because they get part or all of their food from symbiotic bacteria living in their gills. What's really extraordinary, though, is how the bacteria get the energy they need to create this food: not from sunlight, as plants do, but from simple chemicals found in their surroundings – a process called chemosynthesis.

This process is what allows spectacular oases of life to thrive at hydrothermal vents deep beneath the sea's surface. What's less well known is that, far from being limited to the deep vents, animals that rely on chemosynthetic bacteria have turned up in all kinds of places.

Those lucinid clams are common in the shallow waters of the Bahamas, for instance – I grew up collecting their shells on the beach, but never realised what they fed on. Now I'm trying to find out what feeds on them to see how big a role they play in the local ecosystem. Recent discoveries by other researchers suggest chemosynthesis is far more important than anyone imagined. ›

DO ALIENS EAT DARK CARBON?

The discovery that chemosynthesis is far more widespread and important than we thought (see main story) might appear to boost the idea that life can thrive on other worlds even in the absence of light. However, most forms of chemosynthesis require oxygen, so they do still depend indirectly on photosynthesis.

Most – but not all. A few microbial communities have been found that make all the "dark carbon" they need from simple chemicals without relying on oxygen at all. Such communities couldn't survive for long without a renewable supply of the chemicals they require but there may be such supplies where water cycles through hydrothermal vents. And we now know such vents exist on at least one other world: Saturn's moon Enceladus.

In the mud beneath brine lakes 3.5 kilometres down in the Mediterranean, we have also discovered tiny animals that seem to manage without oxygen. However, it's not possible to get much energy from organic compounds without oxygen, which means ecosystems cannot support large, sophisticated predators. We're not going to find giant aliens lurking in Enceladus's ocean.

In 1977, the discovery of giant gutless worms thriving in vast numbers around hydrothermal vents stunned scientists. What did they feed on, where no light can penetrate and little food sinks down from above? It was Colleen Cavanaugh, now at Harvard University, who proposed that they get their energy from the hydrogen sulphide produced by the vents, with the help of chemosynthetic bacteria housed in special organs. In the absence of light, the bacteria use hydrogen sulphide in a reaction to produce "dark carbon". By 1983, Cavanaugh had shown that vent worms do indeed feed on this dark carbon.

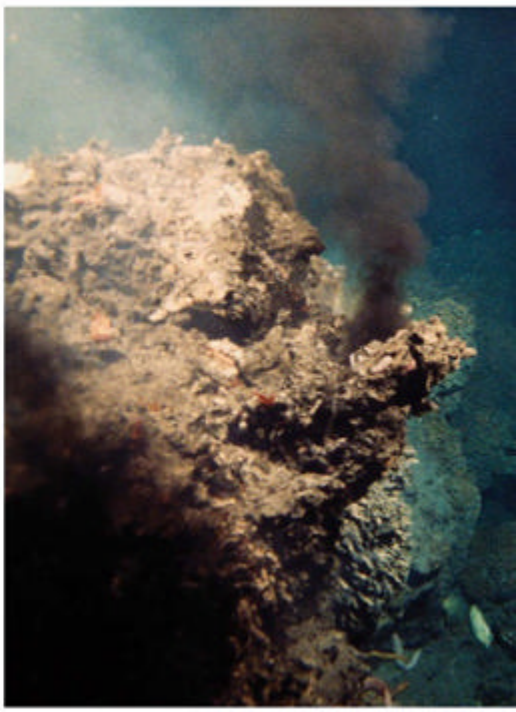
In the same year, similarly rich oases of life were discovered around methane seeps on the sea floor, again thanks to chemosynthetic bacteria. But hydrogen sulphide and methane aren't found only in vents and seeps – they are also produced wherever organic matter decomposes in low-oxygen conditions. In other words, the raw materials for chemosynthesis can be produced by living creatures breaking down food formed by photosynthesis as well as by processes that do not involve life.

Whatever the source of these chemicals, exploiting them usually requires oxygen (see "Do aliens eat dark carbon?", left). This means, Cavanaugh and others realised, that chemosynthetic microbes can thrive wherever there is a boundary between an oxygen-poor environment rich in organic matter and an oxygen-rich environment, from rotting whale carcasses in the deep sea to the mud at the bottom of garden ponds.

"Chemosynthesis is far more widespread and important than we thought"

These microbes are common and often form partnerships with animals. From the early 1980s onwards, biologists began to discover chemosynthetic symbioses in a wide range of invertebrates, from tiny nematode worms and sponges to giant clams, living everywhere from mangrove swamps to the deep sea. These animals shelter the bacteria and help them get the chemicals they feed on and, in turn, the bacteria supply them with food. Many depend so much on the bacteria that their guts are underdeveloped or absent.

Bivalve molluscs are particularly likely to partner with chemosynthetic bacteria. John Taylor, a mollusc specialist at the Natural History Museum in London, estimates that there are hundreds of chemosymbiotic bivalve species, from at least six families. They have evolved symbioses with various kinds of chemosynthetic bacteria on many occasions.



Black smoker hydrothermal vents were the first dark ecosystems found

While there has been much interest in how these symbioses work, the assumption has been that chemosynthesis plays only a very minor role in shallow marine ecosystems. That assumption is turning out to be wrong.

Take the 2 million red knot birds that migrate from Siberia to an area of intertidal mudflats and seagrass beds in Mauritania, western Africa, called the Banc d'Arguin. Quite what all these birds feed on had been a bit of a puzzle. The answer turns out to be lucinid clams. Jan van Gils and Matthijs van der Geest, while working at the Royal Netherlands Institute for Sea Research, have shown that the vast flocks of red knots get half of their food from lucinid clams. The bacteria in the lucinids recycle energy from rotting seagrass that would otherwise be buried in sediments, greatly increasing the population the ecosystem can support.

Recycling energy

This isn't the only example of plant debris being recycled by chemosynthesis. Rivers wash vast quantities of plant material into the sea, but it has been assumed that little entered marine food webs. Then, in 2009, Martin Attrill and his colleagues at Plymouth University Marine Institute in the UK showed that marine relatives of earthworms, called oligochaete worms, can consume this organic matter and pass it up the food chain to the birds and fish that feed on them.

RALPH WHITE/CORBIS

More recently, Nicole Dubilier and her colleagues at the Max Planck Institute for Marine Microbiology in Bremen, Germany, found that these worms have chemosynthetic bacteria living on their skin. In fact, the bacteria are exactly the same as those associated with shrimps, crabs and snails at deep-sea hydrothermal vents. It still isn't clear what the worms gain from the bacteria, but the suspicion is that they help the worms take advantage of the abundance of terrestrial matter that washes into the estuaries.

Around New Zealand, chemosynthesis plays a big role. Here, rivers wash forest litter into fjords, producing sediment very rich in organic material. Dense white mats of free-living chemosynthetic bacteria cover large patches of seabed, and chemosymbiotic clams dominate the animal community. Isotopic studies by Stephen Wing and Rebecca McLeod at the University of Otago in Dunedin show that at depths of around 50 metres, chemosynthesis is the main food source for these communities, which in turn feed local fish such as blue cod and common wrasse, lobsters and sea urchins.

As well as providing food for innumerable marine animals, chemosymbiotic animals can be a valuable food source for us. Near Tinharé Island on Brazil's Bahia coast, for instance, local people harvest lucinid clams from mangrove swamps to eat and to sell to restaurants. The raw flesh is apparently quite tasty, but the gills that house the chemosynthetic bacteria are bitter. Clams like the tiger lucinid are also eaten throughout the Caribbean, a tradition that goes all the way back to the indigenous peoples.

It was the tiger lucinid whose shells decorated the tables on my wedding day. And it is not just a food source. This clam burrows through the sediment housing the knotted roots of tropical seagrass. While studying seagrass in the Banc d'Arguin, a colleague of van Gils, Tjisse van der Heide, noticed that where there were more clams, there seemed to be more seagrass.

The team confirmed that this is the case with field and lab studies. They found that as leaf litter from seagrass decomposes, hydrogen sulphide forms in the sediments. This foul-smelling gas is toxic to seagrass roots so, if it builds up, it inhibits growth. When the clams are present, though, their symbiotic bacteria mop up the gas – and more gas means more food for the clams. So the clams and the seagrass each grow best when the other is present (*Science*, vol 336, p 1432).

"They have been found in everything from tiny worms to sponges and giant clams"

Seagrass supports a wide range of animals, including manatees, turtles and seahorses. It provides nurseries for many commercially important fish and shellfish species. It even helps stabilise coastal sediments and store carbon. All of this, we now know, is thanks in part to the chemosymbiotic clams.

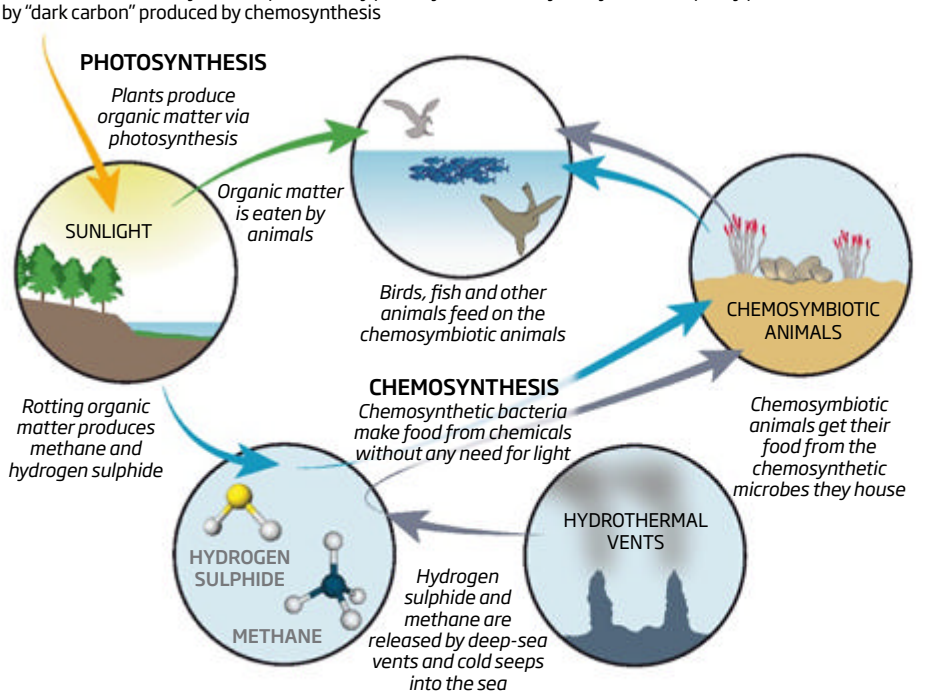
How many more ecosystems could be reliant in part on chemosynthesis? We are just scratching the surface when it comes to understanding the role of chemosynthesis in the ocean. And it's not just the sea. Recent studies have shown that it plays a role in lakes and rivers too. It is amazing that a phenomenon first discovered in the dark depths of the ocean has turned out to be happening in our back yards all this time.

Speaking of back yards, it was my childhood home of the Bahamas where that wedding day comment struck me. I was snorkelling in the seagrass bed just off the beach and noticed dead lucinid shells clumped on the sandy seabed. What caught my attention was that they were all broken in the same odd way – with one shell completely intact while the other was broken off along a growth line. Something is eating these clams – but what? With help from the British Ecological Society and Natural Environment Research Council, I will be returning to the Bahamas to find the culprits and document another chemosynthesis-fuelled food chain. ■

Nick Higgs is a marine biologist at the Marine Institute at Plymouth University, UK. You can find out more about his research at nickhiggs.com

The chemical diet

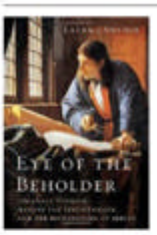
While most animals rely on food produced by photosynthesis, many ecosystems are partly powered by "dark carbon" produced by chemosynthesis



Through a glass, clearly

How we perceive the world today owes a huge debt to two 17th-century giants, finds **Jonathon Keats**

Eye of the Beholder: Johannes Vermeer, Antoni van Leeuwenhoek, and the reinvention of seeing by Laura J. Snyder, W. W. Norton, $27.95/£16.99



IN THE spring of 1694, the Royal Society of London received a letter from Antoni van Leeuwenhoek describing an experiment. Dissecting the eye of a dragonfly and pinning the cornea in front of a powerful lens, van Leeuwenhoek looked out on his street and spied the church steeple multiplied myriad times.

Van Leeuwenhoek was no stranger to the Royal Society. From his home in Delft, the self-taught scientist had dispatched regular accounts of his optical experiments since 1673, when he carried out the first observations of microbes through a home-made microscope.

From dental plaque to blood cells to sperm, nothing was off-limits. Yet what most interested van Leeuwenhoek, says Laura J. Snyder in *Eye of the Beholder*, was "visual perception itself". As it happens, van Leeuwenhoek had a neighbour with similar interests in visual perception and optics. Living just across Delft's Market Square was the artist Johannes Vermeer, who used observation through lenses to craft his paintings.

There's no evidence that the two knew each other, but physical proximity and many common friends make them irresistible subjects for a joint biography. Snyder makes spectacular use of this historical coincidence. As in her previous masterwork, *The Philosophical Breakfast Club*, she ingeniously explores the minutiae of her subjects' lives to reveal sweeping changes in how their world was understood – ones that still resonate today.

NED M. SEIDLER/NATIONAL GEOGRAPHIC CREATIVE

When Vermeer and van Leeuwenhoek were born, just a week apart, in 1632, Delft was renowned for the quality of its lens glass. Although lenses were mainly used in eyeglasses, they were increasingly being incorporated into tools for scientists and artists. The telescope was invented around 1600; within a decade it had been transformed into a scientific instrument by Galileo, who also developed some of the earliest microscopes by adapting telescopes to study insects.

For artists in the 17th century, composition was frequently augmented by concave lenses, which condensed imagery for easier observation, and by convex lenses, which projected scenery on to canvas for more realistic perspectives. That set-up, also used by scientists to observe eclipses, was known as a camera obscura.

According to Snyder, Vermeer avidly experimented with all these aids, exploring "the way the world appears to us through lenses as a way of understanding visual perception". Initially his focus was on simple optical effects, such as the way that a concave lens distorts proportions.

Artificial eyes

Although there's no direct evidence that Vermeer used the camera obscura, Snyder speculates that he began to do so in the early 1660s, and was exhilarated by it. She bases her argument – convincingly – on close visual analysis of his paintings. Moreover, she attributes many of his works' inventive qualities to his experience with it.

One example is the way Vermeer represented shadows. Hues hidden from sight in the darkness of a room become visible when projected on to a screen. By following what the camera obscura showed, Vermeer was able to increase the realism of his work.

Vermeer "used the camera obscura… to experiment with light, to investigate and discover its optical properties", Snyder writes, deftly aligning the artist with his Delft neighbour. "Both… were employing optical instruments as 'artificial eyes' to supplement the natural organs."

Van Leeuwenhoek's mastery of lens-making and microscopy are as extraordinary in their own way as Vermeer's mastery of painting. Developing his own, mostly secret

techniques, he built some 500 single-lens microscopes capable of magnifying objects as much as 450-fold, and performed micro-dissections that would be challenging even today. Nobody approached his technical capability, let alone patience. But as Snyder points out, his greatest achievement was interpretive.

Biology in the 17th century was totally unprepared for the sight of microbes, or even the tails on sperm. To make these discoveries, van Leeuwenhoek "needed to train himself to see what was there, not what he expected to find", Snyder writes.

And that required a critical understanding of perception: like seeing the colour in shadows, seeing the tails on sperm required insight into sight, an awareness that observation isn't passive.

Snyder sometimes overreaches in her effort to fit this notion to van Leeuwenhoek's every dissection and Vermeer's every brushstroke. But that doesn't diminish her larger argument that active observation fundamentally changed art and science in the 17th century, and is "the most radical influence of the seventeenth century on our time".

"Van Leeuwenhoek needed to train himself to see what was there, not what he expected to find"

How radical? Snyder only hints at the reverberations, mentioning the vast amount of interpretation needed to "see" what our new radio telescopes and electron microscopes can reveal about the unknown universe.

While she doesn't discuss how data analysis and visualisation may be distorted by our preconceived ideas, there is clearly much we can learn from Vermeer and van Leeuwenhoek. Observing how they observed, we are primed to scrutinise our own beliefs. ■

Jonathon Keats is an experimental philosopher and artist

How to market outrage

Imagery is everything when it comes to selling ideals, finds **Simon Ings**

Longing for the Bomb: Oak Ridge and atomic nostalgia by Lindsey A. Freeman, University of North Carolina Press, $26.95

Seeing Green: The use and abuse of American environmental images by Finis Dunaway, Chicago University Press, $40

THE past can't be re-experienced. It leaves only traces and artefacts, which we constantly shuffle, sort, discard and recover, in an obsessive effort to recall where we have come from. This is as true of societies as it is of individuals.

Lindsey Freeman, an assistant professor of sociology at the State University of New York, Buffalo, is the grandchild of first-generation residents of Oak Ridge, Tennessee. Once a "secret city", where uranium was enriched for the US's Manhattan Project, Oak Ridge opened its gates to the world in 1949 as America's first "Atomic City": a post-war utopia of universal healthcare, zero unemployment and state-owned housing.

In *Longing for the Bomb*, Freeman describes how residents of Oak Ridge dreamed up an identity for themselves as a new breed of American pioneer. He visits Oak Ridge's Y-12 National Security Complex (an "American Uranium Center of Excellence") during its Secret City Festival, boards its Scenic Excursion Train and cannot decide if converting a uranium processing site into a wildlife reserve is good or bad.

It would have been easy to turn the Oak Ridge story into something sinister, but Freeman is too generous a writer for that. Oak Ridge owes its existence to the geopolitical business of mass destruction, but its people have created stories that keep them a proud and happy community. Local trumps global, every time.

This is good for the founders of communities, but a problem for those who want to wake up those communities to the need for change. As historian Finis Dunaway puts it in *Seeing Green*, his history of environmental imagery, "even as media images have made the environmental crisis visible to a mass public, they often have masked systemic causes and ignored structural inequalities".

Reading this, I was reminded of a talk by author Andrew Blackwell, where he told us just how hard it is to take authentic pictures of some of the world's most polluted places. Systemic problems do not photograph well. Some manipulation is unavoidable.

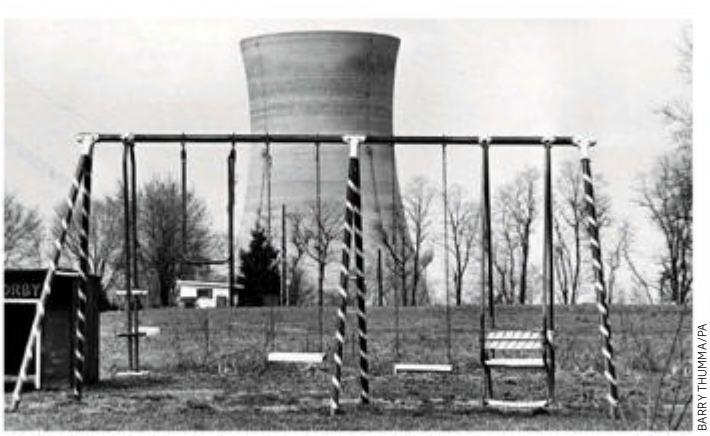
Dunaway knows this. Three months after the nuclear accident at Three Mile Island in 1979, the worst radioactive spill in US history occurred near Church Rock, New Mexico, on lands held by the Navajo nation. It took a week for the event to be reported, once, on a single news channel.

The remoteness of the site and a lack of national interest in Native American affairs might explain the silence but, as Dunaway points out, the absence of an iconic and photogenic cooling tower can't have helped.

The iconic environmental images Dunaway discusses are essentially advertisements, and adverts address individuals. They assume that radical social change will catch on like any other consumer good. For example, the film *An Inconvenient Truth*, chock full of eye-catching images, is the acme of the sincere advertiser's art, and its maker, former US vice-president and environmental campaigner Al Gore, is a vocal proponent of carbon offset and other market initiatives.

Dunaway, though, argues that you cannot market radical social action. For him, the moral seems to be that sometimes, you just have to give the order – as Franklin Roosevelt did when he made Oak Ridge a city. ■

Striking images of cooling towers help make environmental points



BARRY THUMMA/PA

NewScientist Jobs
Incorporating ScienceJobs.com
To apply online visit newscientistjobs.com

East Coast Office
225 Wyman Street
Waltham, MA 02451
Email NSSales@NewScientist.com
Phone 781 734 8770

Department of Health and Human Services
National Institutes of Health
National Institute on Aging

The National Institute on Aging (NIA), a major research component of the National Institutes of Health (NIH) and the Department of Health and Human Services (DHHS), is recruiting for a postdoctoral position in The Section on DNA Helicases, Laboratory of Molecular Gerontology. Research in the Laboratory of Molecular Gerontology involves the study of genomic stability maintenance. The focus of our group is to investigate the functions of DNA helicases defective in premature aging and cancer disorders. The objective of this research is to understand the molecular and cellular roles of human DNA helicases in pathways that are important for the maintenance of genome stability. Genetic and biochemical approaches are used to characterize the roles of helicases in cellular DNA metabolic pathways and the mechanisms of unwinding by human DNA helicases.

Interested candidates must have a Ph.D. or M.D. with less than five years of postdoctoral experience and research experience in molecular biology, and training in mammalian cell culture techniques. Salary is commensurate with experience and accomplishments. Submit letter of interest, curriculum vitae, and references to:

Robert M. Brosh, Jr., Ph.D.,
Senior Investigator NIA-NIH, Laboratory of Molecular Gerontology,
251 Bayview Blvd., Suite 100, Baltimore, MD 21224 USA.
Phone: **410-558-8578**, or E-mail: **BroshR@mail.nih.gov.**

For additional information on this position,
visit **http://www.grc.nia.nih.gov/branches/lmg/rbrosh.htm**

HHS and NIH are Equal Opportunity Employers

Director,
NASA Astrobiology Institute

NASA seeks a new Director for the NASA Astrobiology Institute (NAI). The ideal candidate will be an internationally recognized scientist with proven experience in leading or managing large interdisciplinary research programs or projects, possessed with a vision for leading the Institute into the future.

Applicants for this position should have a broad scientific perspective on astrobiology, experience in conducting interdisciplinary scientific research, and demonstrated skills needed to harness the strengths of disparate research communities towards a greater goal. S/he should understand how to grow a research endeavor and respond to changing budget climates while focusing on maximizing the scientific return on NASA's investments in astrobiology. S/he should have experience in leading a diverse staff ranging from established scientists to support personnel, resource planning, and executing budgets and schedules. S/he should be comfortable with modern information technologies and distributed research teams. NASA is particularly interested in applicants who will find ways to infuse astrobiology into NASA flight missions.

Interested individuals should apply directly to USAJobs at **www.usajobs.gov**

by May 1, 2015.

In the keyword search box, type vacancy number "AR15S0001". Select "Director, NASA Astrobiology Institute", then click "**Apply Online**".

The winning formula for science & research jobs

Let New Scientist Jobs connect you with the top STEM employers

Finding the right employer is essential to your career development. Take your pick of top employers at New Scientist Jobs and advance your career today.

Print Digital Mobile

Find your future at NewScientistJobs.com

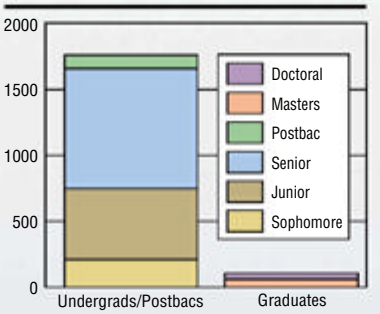
NewScientist Jobs

Annual Biomedical Research Conference for Minority Students (ABRCMS)

Washington State Convention Center • Seattle, WA • November 11-14, 2015

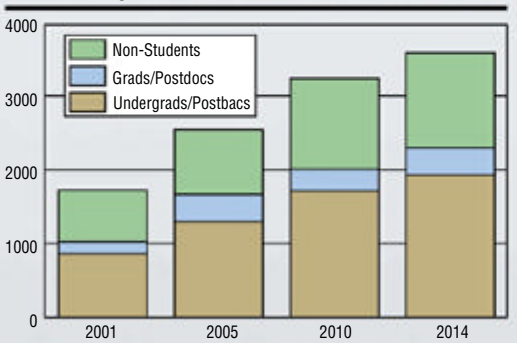
ABRCMS advances undergraduates and postbaccalaureates from underrepresented populations, including those with disabilities, in science, technology, engineering and mathematics (STEM) along the path toward graduate-level training. The conference features 1,700 poster and oral presentations, scientific sessions, professional development and networking sessions, and approximately 325 exhibit booths showcasing summer research and graduate school opportunities.

2014 Abstract Submissions by Education Level



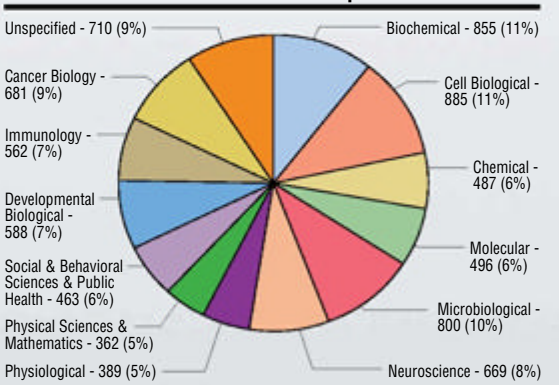
2014 ABRCMS Attendees by Location

ABRCMS Registration



"It was a great opportunity to see the extraordinary research being conducted in the country and also to encourage and offer thoughtful advice to the future scientists."
FACULTY/JUDGE

2014 Distribution of Scientific Disciplines



"Attending and winning in my category was one of the best experiences in my scientific life. Coming from my background, I doubted myself in the past. I now feel confident because when I presented my poster I left like I belonged. This conference really made me believe that I can pursue a career in science."
STUDENT

Important Deadlines

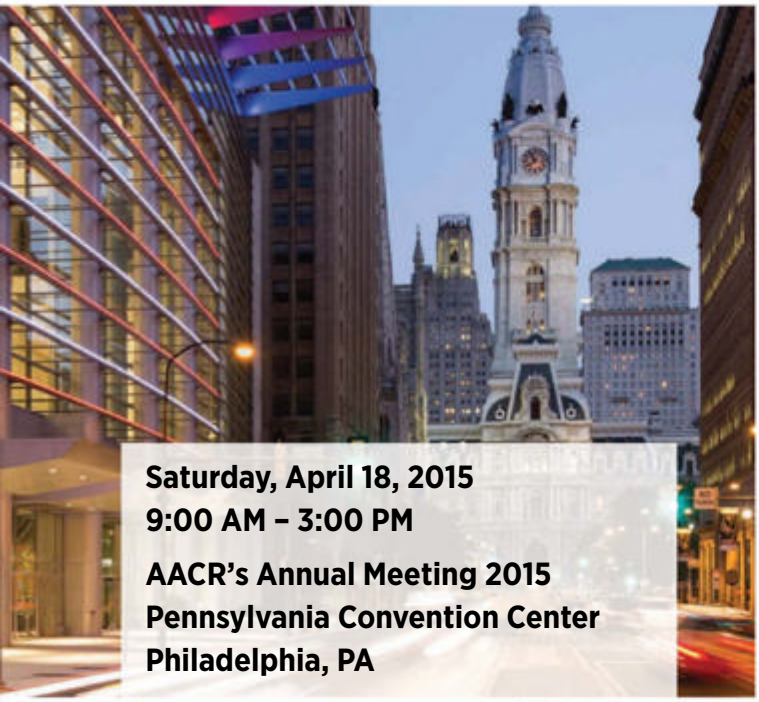
Abstract Submission: .....**September 11, 2015**
Travel Award Application: .....**September 11, 2015**
Judges' Travel Subsidy Application: .....**September 25, 2015**
Discount Registration: .....**October 19, 2015**

For more information, please visit: www.abrcms.org.

facebook.com/abrcms twitter.com/abrcms abrcms@asmusa.org Managed by: AMERICAN SOCIETY FOR MICROBIOLOGY

AACR'S ANNUAL

CANCER AND BIOMEDICAL RESEARCH CAREER FAIR



Saturday, April 18, 2015
9:00 AM – 3:00 PM

AACR's Annual Meeting 2015
Pennsylvania Convention Center
Philadelphia, PA

Saturday, April 16, 2016
9:00 AM – 3:00 PM

AACR's Annual Meeting 2016
Ernest N. Morial Convention Center
New Orleans, LA

Whether you are a job seeker or an employer, this is the Career Fair for you!

JOB SEEKERS: Attendance is FREE. Meet employers from academia, the pharmaceutical industry, and scientific organizations. Be sure to check the box for the Career Fair when registering to attend the AACR Annual Meeting at www.AACR.org/annualmeeting.

Upload your CV/resume today on CancerCareers.org.

EMPLOYERS: Find the scientific talent you are looking for in basic, translational, clinical, and preventative cancer research and biomedicine. Sign up today to take advantage of the opportunities to be a sponsor, exhibitor, or advertiser.

For more information and to sign up for the AACR Cancer and Biomedical Career Fair, go to www.CancerCareers.org, call 215-440-9300, or email CareerFair@aacr.org.

Technical/Research Assistants

The Koch Institute for Integrative Cancer Research, a National Cancer Institute (NCI)-designated Cancer Center, is a state-of-the-art cancer research facility as well as the hub of cancer research on the MIT campus. The Koch Institute (KI) brings together biologists and chemists along with biological, chemical, mechanical, and materials science engineers, computer scientists, clinicians and others, to bring fresh perspectives and an interdisciplinary approach to advancing the fight against cancer. This multi-faceted group of investigators is at the core of the Koch Institute's mission to develop new insights into cancer, as well as new tools and technologies to better treat, diagnose and prevent the disease.

The KI has several exciting Technical/Research Assistant positions open now and in the coming months. These positions are critical to our mission, supporting and enhancing cutting-edge, interdisciplinary, cancer-focused scientific/engineering projects. We are looking for individuals who value creativity, diversity, inclusion, and collaboration. Why not be part of a supportive community that fosters personal and professional development? Once you're here, you'll want to stay.

As a Technical Assistant, you will be part of a dynamic team and will provide technical expertise and support by: organizing and completing experiments and tests by studying project objectives and processes; documenting results; keeping project leader informed; maintaining equipment; maintaining and a safe and healthy work environment; completing experiments and tests; performing protocols; updating job knowledge; exploring opportunities to add value to job accomplishments.

Minimum Qualifications: BS in Biological Sciences or other relevant field; hands-on experience in research laboratory environment; experience informing superiors and peers based on their information needs; committed to exceeding quality standards and providing exceptional services; exhibits meticulous attention to detail; committed to producing accurate and high-quality work; practiced documentation skills; uses multiple resources, quantitative, and qualitative research methodologies to capture and interpret information; aware of basic safety issues; follows safety procedures and maintains a safe work environment; trained in hands-on equipment maintenance.

MIT is an equal employment opportunity employer. All qualified applicants will receive consideration for employment and will not be discriminated against on the basis of race, color, religion, sex, sexual orientation, gender identity, national origin, veteran status, or disability.

Apply online at **careers.mit.edu**, search for keyword "**Koch**."

KOCH INSTITUTE
for Integrative Cancer Research at MIT

UTSA® The University of Texas at San Antonio

Robert A. Welch Endowed Chairs in Chemistry at The University of Texas at San Antonio

The Department of Chemistry at The University of Texas at San Antonio (UTSA) seeks internationally renowned scientists to fill two newly established Robert A. Welch Endowed Chairs in Chemistry. The research area of one Chair is expected to encompass the interface of chemistry and biology. The research area of the other Chair can encompass any area of modern chemistry. Each Welch Chair includes a generous endowment, a highly competitive salary, and ample modern research space. Significant additional financial resources and state-of-the art facilities are available. The scientists occupying these Welch Chairs are expected to play leadership roles in ongoing departmental growth and faculty recruitment. Opportunities are available for collaborative initiatives at UTSA and with nationally renowned area institutions, including the University of Texas Health Science Center at San Antonio and the Southwest Research Institute.

San Antonio is the 7th largest city in the U.S. and features a historical and vibrant downtown area. UTSA is located northwest of downtown San Antonio adjacent to the scenic Texas Hill Country, which provides many recreational opportunities.

Nominations and inquiries can be sent to the Department Chair, Dr. Waldemar Gorski, at the following address: Department of Chemistry, UTSA, One UTSA Circle, San Antonio, TX 78249 or via email (**Waldemar.Gorski@utsa.edu**).

MS in Bioinformatics at Boston University

One of the first programs of its kind, the Bioinformatics Graduate Program offers unique interdisciplinary training in the science, engineering, medicine and ethics of twenty-first century cell biology.

Now awarding MS Merit Scholarships, providing tuition assistance to full-time students on a competitive basis

The Master's degree requires a total of 32 credits. You can complete the program in as little as 18 months, or enroll part-time for a schedule that fits your lifestyle. BU Bioinformatics offers an MS degree in Bioinformatics, or an MS in Bioinformatics with a focus on Translational Medicine

Application Deadlines:
July 1 for fall | December 15 for spring

bu.edu/bioinformatics/

BOSTON UNIVERSITY

Break through with your science career

Find the top tips for moving up, moving on or moving out of your career.

What are you worth? Read the results of our latest annual survey of science salaries, in association with SRG.

Explore the state of careers in science, engineering, technology and maths for women

Find all this in the free New Scientist 2015 Careers Guide
www.newscientistjobs.com/careersguide2015US

NewScientist Jobs

POSTDOCTORAL OPPORTUNITIES

Find these and many more postdoctoral opportunities on our New Scientist Jobs online jobs board!

Go to **www.NewScientistJobs.com**

Enter the Job ID# listed below to read about the position. Find more jobs by entering your criteria into the grey search box.

1401555997	Research Associate I (209959), Bethesda, Maryland. **HENRY M JACKSON FOUNDATION**
1401556256	Postdoctoral Appointee - Coherent Imaging, Lemont, IL **ARGONNE NATIONAL LABORATORY**
1401546598	NASA Postdoctoral Program (NPP) - **OAK RIDGE ASSOCIATED UNIVERSITIES**
1401557328	Postdoctoral position in The Section on DNA Helicases - Baltimore, MD **NATIONAL INSTITUTES ON AGING (NIA)**
1401556624	Postdoctoral Fellow Opportunities - Geisinger Translational and Molecular Medicine Program **GEISINGER HEALTH SYSTEM (GHS)**
1401549261	Postdoctoral Fellow, Molecular Biology (Job Id 20484) - Danville, PA **GEISINGER HEALTH SYSTEM (GHS)**
1401557338	Postdoctoral Research Associate - Seattle, WA **BENAROYA RESEARCH INSTITUTE**
1401552635	Research Fellow, Wagle Lab- Boston, MA **DANA-FARBER CANCER INSTITUTE**
1401559132	Post-Doc Research Fellow, Multiple Myeloma- Boston, MA **DANA-FARBER CANCER INSTITUTE**
1401555504	Postdoctoral Fellowship, Neurobiology - Boston, MA **BOSTON CHILDREN'S HOSPITAL AND HARVARD MEDICAL SCHOOL**
1401557337	Postdoctoral Positions - New York, NY **MOUNT SINAI SCHOOL OF MEDICINE**
1401555439	Postdoctoral position in Molecular Neuroscience, LSU - New Orleans, Louisiana **LSU HEALTH SCIENCES CENTER, NEUROSCIENCE CENTER OF EXCELLENCE**
1401555292	Postdoctoral Position at Purdue University's Birck Nanotechnology Center - West Lafayette, IN **PURDUE UNIVERSITY**
1401556261	Postdoctoral Research Associate in MicroBooNE and Mu2e - Manhattan, KS **KANSAS STATE UNIVERSITY, DEPARTMENT OF PHYSICS**
1401550138	Postdoctoral Recruitment Day "Summer Preview" is June 4-5 in Ann Arbor, Michigan **UNIVERSITY OF MICHIGAN MEDICAL SCHOOL (UMMS)**
1401546596	Postdoctoral Positions - **UNIVERSITY OF ALABAMA AT BIRMINGHAM (UAB), OFFICE OF POSTDOCTORAL EDUCATION**
1401487465	Opportunities at Lerner Research Institute - **CLEVELAND CLINIC FOUNDATION, LERNER RESEARCH INSTITUTE**
1401545856	Faculty and Postdoc Opportunities - **UNIVERSITY OF CALIFORNIA, IRVINE**
1401546595	Grant Programs for Scientific Research and Teaching - **BURROUGHS WELLCOME FUND**
1401557687	Postdoctoral opportunity in Translational Oncology **ASTRAZENECA US**
1401557067	Postdoctoral Opportunity in Cellular Signaling Dynamics, Translational Safety **ASTRAZENECA US**
1401557066	Post Doctoral Opportunity-Neuroscience, USA **ASTRAZENECA US**
1401557065	Post Doctoral Opportunity - Discovery Sciences, Waltham USA **ASTRAZENECA US**
1401557063	Postdoctoral Opportunities in Discovery Sciences (Structure & Biophysics and Chemical Biology) **ASTRAZENECA US**
1401557062	Post Doctoral Opportunity Oncology iMED, Boston, USA **ASTRAZENECA US**
1401557059	Post Doctoral Opportunities in Drug Safety, Boston USA **ASTRAZENECA US**
1401557057	Post Doctoral Opportunity, Neuroscience, Baltimore, USA **ASTRAZENECA US**
1401556910	Postdoc in Stem Cell Biology/Neuroscience **ASTRAZENECA US**
1401556789	Post Doctoral Opportunity - Oncology NGS Bioinformatics, USA **ASTRAZENECA US**
1401555611	Research Associate, Biotherapeutics Job **CELGENE**
1401553672	Research Associate, Biotherapeutics Job - San Diego, CA **CELGENE**
1401557430	Research Associate IV **THERMO FISHER**
1401560815	Post Doctoral Opportunity - Oncology NGS Bioinformatics, USA **ASTRAZENECA US**
1401560446	Post Doctoral Research Fellow B Cell Response to Vaccination **FRED HUTCH**
1401559818	Post Doctoral Research Fellow Viral Infection Modelling **FRED HUTCH**
1401559816	Post Doctoral Research Fellow **FRED HUTCH**
1401559802	Statistical Research Associate I II **FRED HUTCH**
1401559772	Statistical Research Associate I III **FRED HUTCH**
1401559739	Post Doctoral Research Fellow Physics Engineering and Biology **FRED HUTCH**
1401559725	Post Doctoral Research Associate Cancer Drug Therapy Discovery Applying Functional Genomics **FRED HUTCH**
1401559668	Post Doctoral Research Fellow Molecular Analysis of Transcriptional Regulation **FRED HUTCH**
1401559761	Post Doctoral Research Fellow Computational Biology **FRED HUTCH**
1401559798	Post Doctoral Research Fellow Transplant Immunology **FRED HUTCH**
1401559773	Post Doctoral Research Fellow Immunobioengineering **FRED HUTCH**
1401559814	Post Doctoral Research Fellows Quantitative Infectious Disease Methods **FRED HUTCH**
1401559817	Post Doctoral Research Fellow Humoral Immunity to Vaccines and Infection **FRED HUTCH**

California Polytechnic State University
TENURE TRACK POSITION
ORGANIC CHEMISTRY OR BIOCHEMISTRY

CAL POLY
SAN LUIS OBISPO

Teaching assignments will be in organic chemistry or biochemistry with substantial assignments in general chemistry for majors and non-majors. The successful candidate will be expected to play a role in pedagogy and curriculum development for our chemistry offerings. We encourage applications from candidates who plan to incorporate this curriculum activity into their research program. Successful candidates must be committed to high-quality undergraduate education and will be expected to develop and maintain an active undergraduate research program. Publishable research that engages undergraduates is expected. Salary and rank are commensurate with qualifications and experience. Appointment is anticipated at the assistant professor level, but appointment at an advanced level may be possible for a highly experienced candidate.

A Ph.D. in biochemistry, chemistry, or related discipline is required at the time of hiring. Area of research specialization is open but specializations in organic chemistry or biochemistry are preferred. The Department of Chemistry and Biochemistry offers B.S. degrees in both chemistry and biochemistry. The department also serves many technical programs in the University. Students may choose concentrations in Polymers and Coatings, Molecular Biology, or a focused Master's program in Polymers and Coatings Science. The department is committed to providing each student with a capstone experience through a faculty-facilitated senior project. More information may be viewed at **http://www.calpoly.edu/~chem**.

To apply, go to **WWW.CALPOLYJOBS.ORG** and complete a required online faculty application and submit to requisition #103595. Applications must include: online application form, cover letter addressing the appropriate qualifications listed above, current resume, statement of teaching philosophy, a proposal for scholarship, and evidence of successful teaching. These and other materials such as syllabi can be attached as PDF documents to the online form. Please be prepared to provide three professional references with names and email addresses when completing the on-line application.

Screening of applicants begins April 20, 2015; complete applications received after that date may be considered. Finalists will be required to submit a 10-minute video sample of their teaching. The topic for the video will be "Equilibrium," and the target audience will be freshmen in a year-long, science-majors general chemistry course. Preliminary telephone interviews will be held in late April and finalists asked to interview in May, 2015 for a starting date of September, 2016. Official transcripts will be required prior to an appointment.

For questions, please contact Dr. Nanine Van Draanen at **nvandraa@calpoly.edu**.

At California Polytechnic State University, San Luis Obispo, we believe that cultivating an environment that embraces and promotes diversity is fundamental to the success of our students, our employees and our community. Bringing people together from different backgrounds, experiences and value systems fosters the innovative and creative thinking that exemplifies Cal Poly's values of free inquiry, cultural and intellectual diversity, mutual respect, civic engagement, and social and environmental responsibility. Cal Poly's commitment to diversity informs our efforts in recruitment, hiring and retention. California Polytechnic State University is an affirmative action/equal opportunity employer. EEO.

UAB THE UNIVERSITY OF ALABAMA AT BIRMINGHAM

Postdoctoral Positions

The University of Alabama at Birmingham (UAB) is one of the premier research universities in the US with internationally recognized programs in AIDS & bacterial pathogenesis, bone biology & disease, cancer, diabetes & digestive & kidney diseases, free radical biology, immunology, lung disease, neuroscience, trauma & inflammation, and basic & clinical vision science among others. UAB is committed to the development of outstanding postdoctoral scientists and has been consistently ranked in recent years as one of the top locations among US universities for training postdoctoral scholars.

UAB is recruiting candidates for postdoctoral positions in a variety of research areas. UAB faculty are well funded (top 25 in NIH funding), utilize multidisciplinary approaches, and provide excellent research training environments that can lead exceptional candidates to entry level positions in academia, government or the private sector. Full medical coverage (single or family), competitive salaries/stipends, sick leave, vacation, and maternity/paternity leave are offered with every position as well as AD& D, disability & life insurance. Depending on the source of funding, retirement benefits may also be available. Birmingham is a mid-size city centrally located in the southeast near beaches and mountains and enjoys a moderate climate for year round outdoor activities and a cost of living rate lower than most metropolitan areas.

Visit our website at **www.uab.edu/postdocs/openings**, to view positions. See info also on MERIT Program, an NIH IRACDA program. Send your CV to the contact name for the positions that you are interested. University of Alabama at Birmingham, Office of Postdoctoral Education, 205-975-7020.

UAB is an equal employment opportunity employer.

Bates College,
Faculty Position, Biology

Visiting Assistant Professor of Evolution and Conservation Biology - Biology R2706

Location: **Lewiston, Maine**

The Biology Department of Bates College invites applications for a 1-year, full-time faculty position in evolutionary biology and conservation biology, beginning 1 August 2015. Teaching responsibilities comprise five courses per year, including an upper-level evolution course, a conservation biology course, two offerings of an entry-level evolution course open to all majors, and an additional course related to conservation biology or environmental studies. Supervision of undergraduate thesis research is also expected.

Qualifications

PhD or ABD required by start date. We welcome applications from all individuals with the ability to contribute to the college's continuing commitment to social and cultural diversity, inclusiveness, and the transformative power of our differences. The search committee asks applicants to identify their strengths and experiences in these areas and describe how their research, teaching, and/or outreach can further this goal.

Application Instructions

Review of applications begins 15 March 2015, and will continue until the position is filled. Applicants should submit in PDF format, a cover letter, curriculum vitae, unofficial graduate transcripts, and statements on teaching and research. Please also arrange for the submission of three letters of recommendation, in PDF format. Employment is contingent upon successful completion of a background check.

Please email **academicservices@bates.edu** for further consideration, and don't forget to mention you saw us in New Scientist Magazine.

A ration of health

From Christopher Burke
Your special report on the future of healthcare raises some good points, but it doesn't address the fundamental problem of the UK's National Health Service (21 March, p 22). Nye Bevan introduced the NHS in 1948 for everything "from the cradle to the grave", free of charge at the point of need. It was excellent by the standards of the day, but in the day "everything" was not very much.

There was midwifery, some neonatal care, general practice, plenty of lung cancer (always fatal), and so on. Life expectancy was 65 years. There was a culture of self-reliance, and little appetite for prolonging life for the sake of it. So the costs of the early NHS were easily met by a tax increase.

More diagnostic tests and expensive scans are now used and more treatments are possible, some of them absurdly expensive. There is an obesity epidemic, diabetes incidence has more than trebled, and a rising incidence of mental health problems is poorly addressed. Above all, a huge increase in life expectancy and consequent morbidity has exploded the demographic time bomb that we health workers discussed in the 1960s.

"Everything from the cradle to the grave" must be replaced by defining what the NHS will and will not do. The required alteration in public expectations will be as radical as the introduction of the NHS itself was in its time. But there are no votes in that.
Sidmouth, Devon, UK

Fuelling cyclones

From Michael Henderson
In ripping through Vanuatu, Tuvalu and the Solomon Islands (21 March, p 6), cyclone Pam has become the benchmark for massive weather events that occur far away from the energy consumption responsible for our warming weather patterns.

These Pacific islands are the victims of the industrial world's energy excesses. How much will it cost to help these island nations rebuild, and more importantly, how much will the industrial world contribute – or for how much longer will it keep making band-aid repairs?

The easiest path to take really is to discontinue fossil fuel consumption and become a renewable world. Otherwise, the Pacific nations will be battered out of existence.
Gold Coast, Queensland, Australia

Gateway doubt

From Peter Hajek
Your interview with Denise Kandel gave the impression that mouse experiments show there is such a thing as a "gateway effect", in which nicotine use leads to the use of other drugs (7 March, p 28). But we have solid and clear human data.

Over the past 60 years, the prevalence of smoking among young men in the UK has declined from 80 per cent to under 20 per cent. If use of nicotine increased use of other drugs, this steep reduction in smoking would have resulted in a drop in the use of other drugs as well. There is no sign of this. The gateway effect is an attractive hypothesis but it does not exist.
London, UK

Migraine et al.

From Janine John
I was very interested to read your recent article on migraine, and especially about the many different categories that exist (7 March, p 38). I was treated unsuccessfully for migraine for 14 years, before finally being diagnosed instead with the lesser-known condition called cyclical vomiting syndrome.

Like migraine, CVS is episodic. It is characterised by severe nausea, retching and vomiting, which occurs five or six times per hour at the peak of an attack.

CVS seems to be associated with migraine, although no one yet understands the relationship between the two, or why CVS occurs. There is more about the condition at cvsa.org.uk.
Windermere, Cumbria, UK

From Nancy Wood
As a "migraineur" I appreciated your recent update on migraines. A report in *New Scientist* led me to search for a vagal nerve stimulation device (17 August 2013, p 12). It has profoundly helped my condition.

However, reading and concentrating on articles with such busy graphics is hard on the migraine brain.
Cobble Hill, British Columbia, Canada

The editor replies:
■ Once again, we advise readers to discuss any migraine treatments with their registered physician.

Machines who think

From Peter Norton
I was shocked that the creators of iCub appear not to understand the implications of their effort to build a robot with a self (21 March, p 36). They are striving to create "consciousness".

Researcher Tony Prescott writes: "Sometimes it even leaves me with the surprising feeling

that 'someone is home'." I can well accept, as can he, that being sentient is the accumulation of processing power and decision-making abilities. His effort to create a sentient being should therefore be governed by the same regulations as primate experimentation.
Aylsham, Norfolk, UK

Red Lady deodorant

From Neil Doherty
I was intrigued by the Red Lady of El Mirón (21 March, p 8), and I would venture to explain why there is so much pollen in the cave where she was buried.

We can be sure that, as the article stated, this woman was highly venerated, and also that the people who buried her would not have been able to halt decomposition. This points to a problem that they were clearly respectful enough to put up with.

The pollen may, then, indicate the use of copious flowers to cover up the smell. These would also decay and so be constantly replaced, leaving large amounts of pollen.
Barnsley, South Yorkshire, UK

Alien odds

From Pushkar Piggott
I was disappointed that Bob Holmes failed to mention Ernst Mayr in his otherwise excellent article on how evolution might replay (14 March, p 32). Mayr is the

undoubted pioneer in this area, and in his essay "The probability of extraterrestrial intelligent life" (in *Extraterrestrials: science and alien intelligence*), he identified a series of eight or 10 ridiculously unlikely stages which life has passed through en route to evolving intelligence. Some of these we have greater insight into today, but most are as far-fetched as ever.

This side of the debate is visited infrequently these days: we seem to prefer the more sensational claims of SETI physicists.
Cygnet, Tasmania, Australia

Breaking a butterfly

From Stuart Leslie
Once again I have to read nonsense about the "butterfly effect," this time in your article on chance (14 March, p 30). A small event may indeed have large consequences if all the effects and effects of effects are linked in a very direct and linear way.

Hurricanes or tornadoes, however, are massive events composed of an effectively infinite series of small events or causes such that you could remove thousands, or tens of thousands, of events the magnitude of a butterfly flapping its wings without affecting the major event in any way.

The butterfly's flapping is swamped and cancelled out by the other events. And of course, the system is completely non-linear.
Dorrigo, New South Wales, Australia

Ungodly aspirations

From Connaire Kensit
Comments from E. O. Wilson (24 January, p 28) and subsequent letters on atheism, agnosticism and god all assume these terms have a well-defined meaning agreed by all. But they do not.

To me agnosticism is the insistence that it's wrong to pretend to know what you don't know, but to Chris Ford it's "the assertion that the existence of god is unprovable" (28 February, p 54). If we can't even know whether god exists, we certainly can't know what she may want of us, so our lives, beliefs and ethics must remain godless. Thus agnosticism necessarily implies godlessness – also known as atheism.
London, UK

From Alan Webb
Steven Miles says "True scientists would not accept such a major axiom [as the existence of god] without proof" (21 February,p 54). True scientists would also not accept the axiom that there is no god without proof.

True scientists might decide that "the weight of evidence suggests" a particular conclusion,

but seldom does science state a certainty. True scientists are good at saying: "I don't know."

Miles says that agnosticism is untenable, and just shows that one is afraid of the word "atheist". This is nonsense. Being an atheist is just as irrational as being a theist. When Miles can prove god does not exist, I'll be an atheist. Until then, I'm with E. O. Wilson.
Boulder, Colorado, US

From James Whalley
Chris Ford says that agnosticism is a more scientific position than atheism or theism (28 February, p 54). However, if someone told me there were fairies at the bottom of their garden, I wouldn't say that I was agnostic about it, simply that I didn't believe it.

Since I think the chances of there being any kind of god are about the same as fairies existing, I am quite happy to call myself an atheist.
Howick, Quebec, Canada

Sellotape sunstone

From Neil Downie
I found Philip Ball's account of the search for Viking "sunstones" (21 March, p 40) fascinating. You can easily try out something similar yourself. First find some polarised glasses, such as those 3D specs from the cinema. Now make yourself a small square with one to six layers of Sellotape randomly stuck together.

If you look through the glasses at the square, backlit by a computer screen set to display a uniform light blue or white, you will be surprised to find that the square looks like a prettily coloured Mondrian painting, with different colours depending upon the number of overlapping layers. Now go outside and look at the square against different parts of a cloudy sky. You will find that the Mondrian is lifeless near the sun or opposite, but springs into nice colours at right angles.

The effect works nearly as well with a piece of calcite. Maybe Viking sailors made their own Mondrians out of thin stuff like sheep gut or mica?
Basingstoke, Hampshire, UK

Domestic dinosaurs

From Alex Dolby
Thank you for "A world without chickens" (21 March, p 42). We now know that birds are dinosaurs.

The 22 billion domestic chickens alive must surely make them the most successful dinosaur species ever. But not even chicken dinosaurs are immune from extinction.
Barham, Kent, UK

Little England

From Ben James
Your article on the genetic legacy of the UK states "there are inexplicably stark differences between inhabitants in the north and south of the Welsh county of Pembrokeshire" (21 March, p 54). This can be explained by south Pembrokeshire being a stronghold of the Normans in Britain. As I recall local history, the Norman king brought in Flemish people to subdue the unruly local population and farm the land. Welsh is not spoken by people local to Southern Pembrokeshire and the area is often called "little England beyond Wales".
Cardiff, UK

The coolest shades

From Richard Epworth
David Hambling describes a weapon that disturbs vision by heating the eyeball with infrared radiation (7 March, p 44). This will, fortunately, be cheap and easy to nullify. I foresee that infrared blocking sunglasses will become the "cool" eyewear for the military and anyone planning to riot.
Sawbridgeworth, Hertfordshire, UK

For the record

We said that the largest value that can be represented by a 32-bit integer is 2,147,483,647 (13 December 2014, p 21). Our programs would run safely if we got our data types right: we meant that a *signed* 32-bit integer can store values from -2,147,483,648 to 2,147,483,647.

Letters should be sent to:
Letters to the Editor, New Scientist,
110 High Holborn, London WC1V 6EU
Fax: +44 (0) 20 7611 1280
Email: letters@newscientist.com

Include your full postal address and telephone number, and a reference (issue, page number, title) to articles. We reserve the right to edit letters. Reed Business Information reserves the right to use any submissions sent to the letters column of *New Scientist* magazine, in any other format.

PAUL MCDEVITT

BEMUSEMENT was a widespread reaction to 47 US senators – Republicans all – posting an "open letter" to Iran in early March, advising the country that it was wasting its time hammering out a deal to limit its nuclear activities with US president Barack Obama and five other leaders (22 November 2014, p 7). Without the approval of Congress, they wrote, it would be a mere executive agreement that Congress could change or a future president nullify at will. As legal experts stampeded to point out, none of that is true.

Many of these senators are lawyers. All employ them. Surely, they knew that? Sadly for *New Scientist* readers – and other members of what a senior adviser to Republican president George W. Bush dismissively and disparagingly called "the reality-based community" – if you want to believe something badly enough, facts just get in the way.

A week later, 30 senators sent a letter to Obama's health and agriculture secretaries, "concerned with the scientific integrity" of a committee that, they said, had recommended the removal of "lean meat" from US dietary advice. As the Center for Science in the Public Interest sniffed, "the Senators could not have read… much past page three, since page four clearly states that 'lean meats can be a part of a healthy dietary pattern'."

Intriguingly, many of those also signed the Iran letter, and 23 are on a roster of climate deniers (bit.ly/Caucus2015). Fact-intolerance seems to be habit-forming.

FEEDBACK would like to record that David Icke and co-defendants have agreed to pay CAN$210,000 (£113,000) in damages and legal costs to settle a libel action by a Canadian activist lawyer, Richard Warman. Distribution of Icke's book *Children of the Matrix* must be discontinued for containing defamatory material. Icke is, of course, the former football commentator who in 1991 told TV interviewer Terry Wogan that he was the Son of God, and who now holds that we are in thrall to an international banking conspiracy of shapeshifting lizards who are of no particular Earthly religion, oh no. That is all.

WHAT, we asked, should we call the phenomenon of spelling errors that reveal an accent (21 February)? Readers dug into their Greek, always a source of the scienciest neologisms. Alexander Pettigrew came up with "merophones" using the prefix "mero-" meaning "partly". Lawrence D'Oliveiro says "why, homeophones, of course," from the Greek "similar". Grant Hutchison recalled, as we often do, "the theological debate between the Homoousians (who held that the Father and the Son were of identical substance) and the Homoiousians (who held that They were of similar, but not identical, substance)" and therefore proposes "homoiphones".

GOING back to English roots, Ben Haller proposes, on the grounds that the phenomenon of accent-induced semantic confusion depends on one's mental state, that the results be "headphones". In a linguistic grey area, Alex MacDonald finds "duplocates".

MEANWHILE, Dom Watt has come up with the apparently almost entirely original "nibboleth," which "may come in useful when spellings 'go brogue', so to speak." He also reports actual research on the question: Uta Papen and Kevin Watson at Lancaster University, UK, are gathering data on "the connection between UK children's spelling and their speech". We await the results with interest. Not least out of gratitude for this, we will henceforth collect "nibboleths".

SIX readers took us to task for our purported example of an actual homophone, "which witch". In their various flavours of Scots the sounds "w" and "wh" are quite distinct. Are there any pairs of words whose pronunciation is identical in all accents and dialects? How many have to agree on a pronunciation for it to be an accent, not an idiosyncrasy? The usual definition, "a language is a dialect with an army and a navy", doesn't quite cut it here.

FEEDBACK is reminded by the above phenomena of our observation that anyone speaking on the news about "pleece" has probably spent a lot of time in friendly meetings with the constabulary and may have gorn native. That struck us in the late phase of our picaresque past, in which we were regularly meeting with people who refer to themselves as "Senior Pleece Officers".

Are there other examples of semantic-accentual confusion related to occupations, rather than to regional culture? Can we look forward to nibbolethic determinism?

FINALLY, returning us to the legislative suspicion of truth, John Leland directs us to a certain previous governor of Alaska discussing "that 800-pound elephant in the room at the White House". *Prospect* magazine refers to this interview as "Peak Palin".

Filthy socialist European readers and those who conspiratorially welcome our new UN black-helicopter metricated overlords will recognise 800 pounds as around 360 kilograms, or a little over one-thirteenth of the mass of Feedback's standard 5-tonne African elephant. Are Sarah Palin's elephants very hungry?

You can send stories to Feedback by email at feedback@newscientist.com. Please include your home address. This week's and past Feedbacks can be seen on our website.

Would you dare open junk mail offering a "free pre-paid cremation"? Andy Johnson-Laird fears "it might be the death of me"

Living in the past

The number of my direct ancestors alive at any given time increases the further back you go. However, eventually that number is reduced to the handful who were the putative ancestral Eve and Adam, around 200 million years ago. When was the number of my direct ancestors that were alive together greatest, and how many were there?

As someone who has researched my family tree and works in numerical computation, this is something I've considered. The challenge is to try to quantify it, and create a model that seems reasonable.

It's correct that the number of your ancestors doubles each generation prior to you, and we can assume a generation typically covers 25 years. As we go back in time, however, there is also the issue of our planet's dwindling population. At some point, your ancestors would theoretically exceed the global population at that time. In our model we'll use readily available estimates for global population at each generation, rounded to 1 million.

Having researched my family tree beyond 18 generations, I have realised that many complications can affect such calculations. One of these is that families could be quite large, with tens of children, so the descendant tree becomes quite broad. Another is that multiple siblings in one family may become the partners of siblings in another branch, which has the effect of tangling the tree.

We'll ignore these complications because they are too variable. And we should assume that at any one time, roughly three generations of your ancestors are alive, which is something else the model has to take into account.

The question then becomes: as best we can calculate, how many generations ago did the number of your ancestors exceed one-third of the estimated global population? (The other two-thirds of the population are their parents and are by default also related to you.) You are generation 0 and I have assumed you to have been born in 2000 as a baseline, when

"It appears that everyone alive today shares their ancestors from the early 1300s and before"

global population was 5.75 billion. In this model, generation 1 (your parents) is born in 1975 and numbers two people in an estimated global population of 4 billion. Generation 2 contains four grandparents born in 1950, population 2.5 billion. This continues until approximately generation 27, in the year 1325, when you have 134,217,728 million ancestors. Those people and their parents make up the entire global population at the time. Prior to this point, the number of your ancestors reduces with each generation, as does the global population.

Interestingly, it appears that everyone alive today shares their ancestors from the early 1300s and before.

David Morton
Geeveston, Tasmania, Australia

Toil and bubble

My daughter was blowing bubbles from a pot she bought from a toyshop. We were surprised to see that the bubbles varied in colour. Some were blue, some green, some red or pink or orange. And sometimes the outer skin of the bubble appeared to be one colour and the inside another. At first we thought it must be caused by their size or their angle to the sun. But it wasn't. Small or large bubbles could be the same colour, and the colour remained the same wherever the bubbles drifted. Different colours would come from a single blow of the soap substance used to create them. So we decided it must be down to the chemistry of the soap. Can anybody explain further?

The physics of soap bubbles is a fascinating subject. The colours are most commonly caused by thin-film interference between light rays reflected from the outer and inner surfaces of the bubble. Depending on the thickness of the bubble wall, certain wavelengths of light will interfere constructively, giving rise to strong colours. As the bubble evaporates, the wall thickness will change and hence so will the colours.

Because the soapy water tends to flow downwards under gravity, the thickness of the bubble wall may also vary from top to bottom, giving rise to horizontal bands of colour. This can be reduced by thickening the soap solution, for example by adding glycerol.

When the bubble wall becomes very thin – thinner than the wavelength of visible light – the colour will disappear. These regions are transparent but may appear dark because they are usually surrounded by coloured ones. The bubble will burst a few seconds after these patches appear.

Colours can also be produced by adding dyes to the soap solution. Most water-soluble dyes will not work, however, because of the thinness of the bubble walls, and because the water collects at the bottom of the bubble. The dyes need to bind to the soap used to make the solution.

A local ice rink has regular "kiddy club" sessions for toddlers, and they very often make soap bubbles for the children. The cold air and high humidity allow the bubbles to persist for up to a minute, and they show quite spectacular colours.

Bill Tango
Manly, New South Wales, Australia

This week's question

HOLE NUMBER

What happens when a black hole is swallowed by another black hole?

Jamie Malone
London, UK

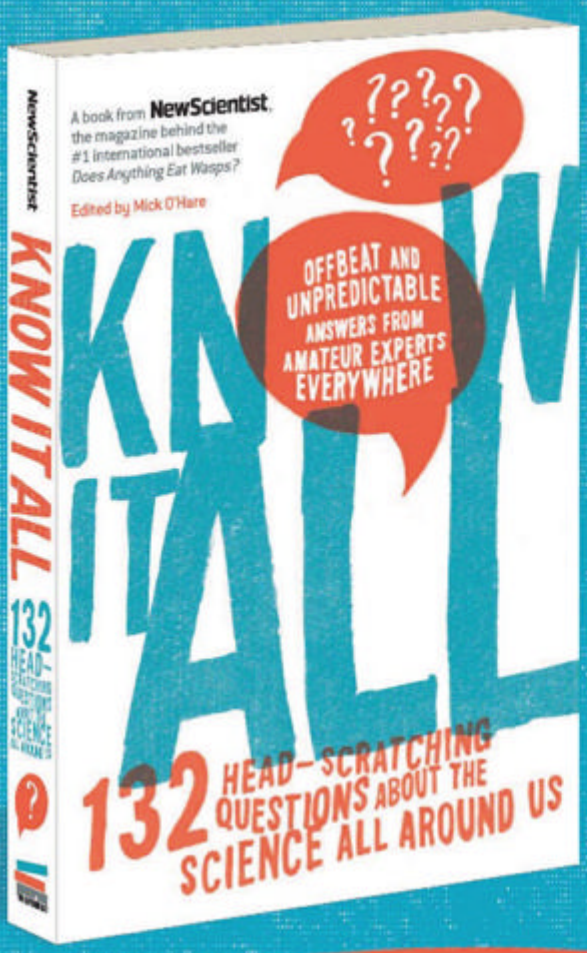
The writers of answers that are published in the magazine will receive a cheque for £25 (or US$ equivalent). Answers should be concise. We reserve the right to edit items for clarity and style. Please include a daytime telephone number and an email address if you have one. New Scientist retains total editorial control over the published content.

Reed Business Information Ltd reserves all rights to reuse all question and answer material that has been submitted by readers in any medium or in any format and at any time in the future.

Send questions and answers to The Last Word, New Scientist, 110 High Holborn, London WC1V 6EU, UK, by email to lastword@newscientist.com or visit www.newscientist.com/topic/lastword (please include a postal address in order to receive payment for answers). Unanswered questions can also be found at this URL.

THE BAFFLING, TRIVIAL, CURIOUS, OR STRANGE . . .

KNOW IT ALL



The latest book in *New Scientist* magazine's bestselling "Last Word" series presents 132 science questions and answers from amateur experts and curious minds everywhere. Find the answers to the **microscopic** (*Why do sand particles on a beach seem to reach a certain grain size and then reduce no further?*), the **puzzling** (*How did the Romans express fractions?*), the **hypothetical** (*If humans lived in a zero gravity space station away from the sun, would skin still wrinkle and sag?*), and the **practical** (*What's the best strategy for getting through multi-lane traffic jams as quickly as possible?*)—any topic is fair game!

KNOW IT ALL: *132 Head-Scratching Questions About the Science All Around Us*
$14.95 • Available in trade paperback and as an ebook wherever books are sold

A *GUARDIAN* TOP 10 SCIENCE AND TECHNOLOGY BOOK

"The experts at *New Scientist* magazine have published a book that answers some of the oddest but most entertaining questions they've been asked."
—DAILY MAIL

"Explain[s] some of life's great mysteries."
—REVEAL

ALSO AVAILABLE
Nothing: Surprising Insights Everywhere from Zero to Oblivion
$14.95 • Available in trade paperback and as an ebook wherever books are sold

NewScientist
THE EXPERIMENT
@experimentbooks
theexperimentpublishing.com